Experts Forum on Public Health Impacts of Wet Weather Blending

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Blending and Wet Weather Operations: An Engineering Perspective

Engineering Experts Panel

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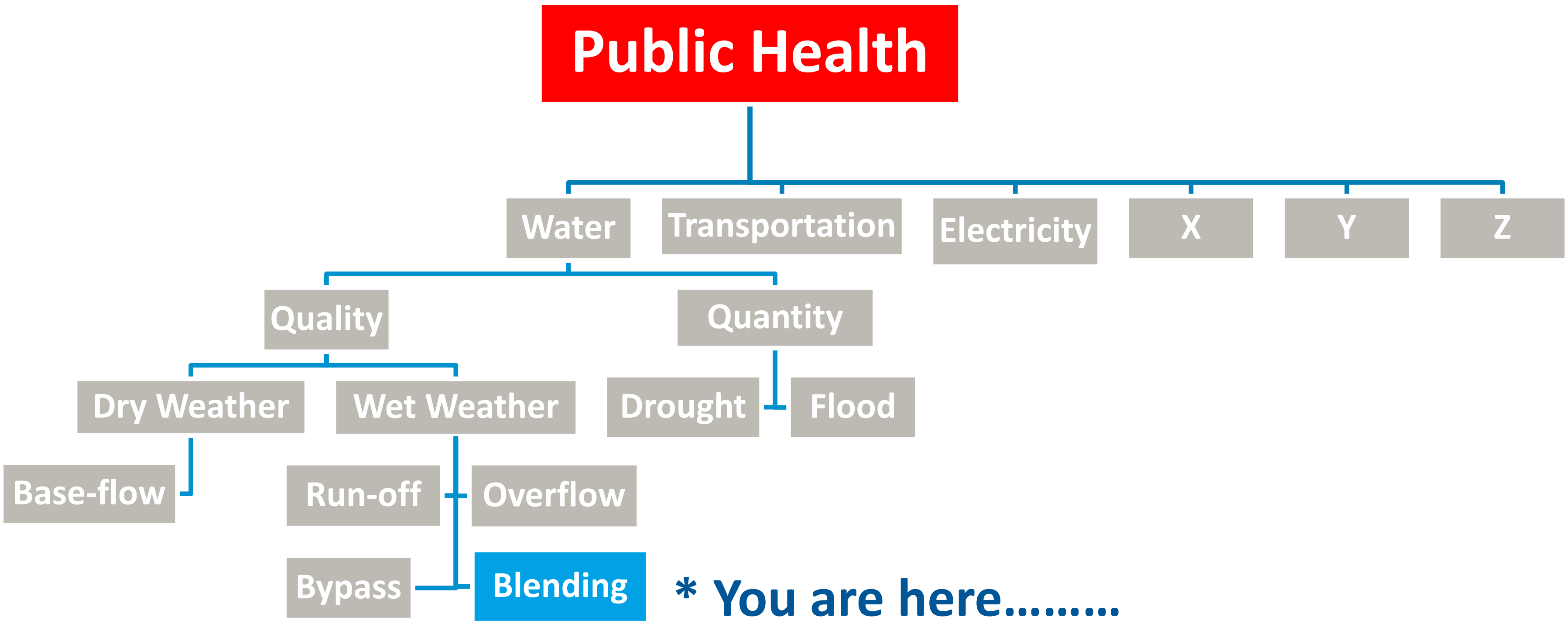
Blending and Wet Weather Operations: An Engineering Perspective

- Executive summary
- The challenge of managing wet weather flows in POTWs
- Wet weather flow management options
- Recent case studies of wet weather flow management
- Recent guidance documents
- Summary points

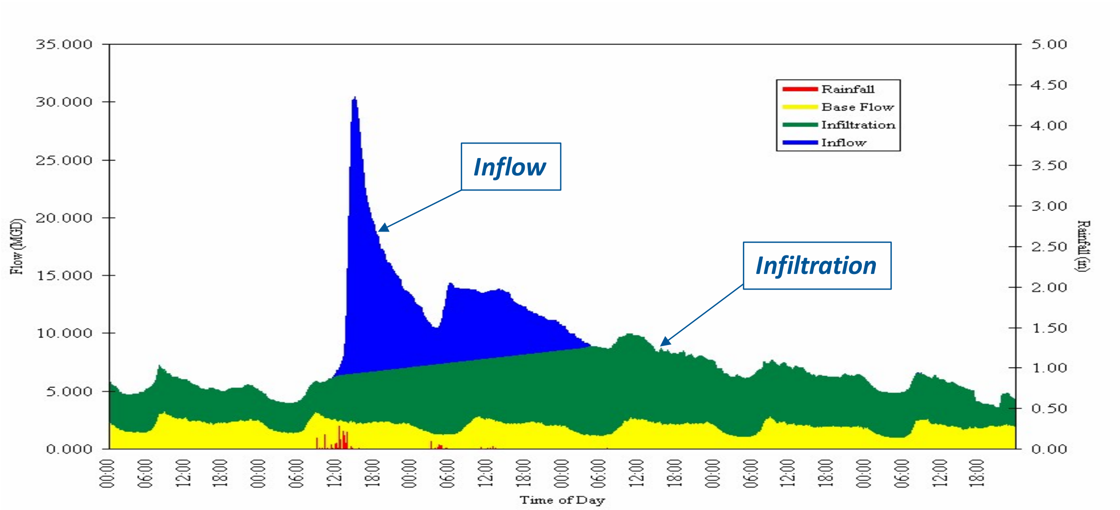
Aspects of Public Health……

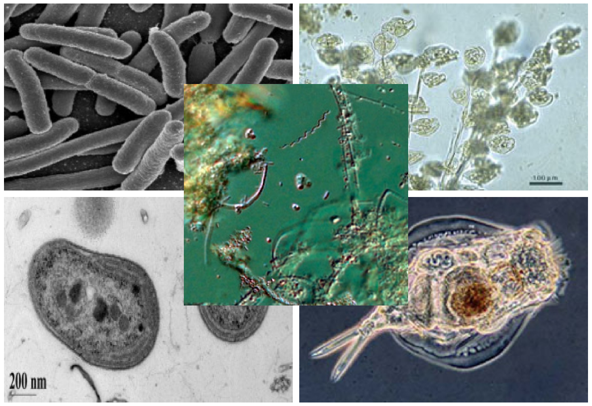


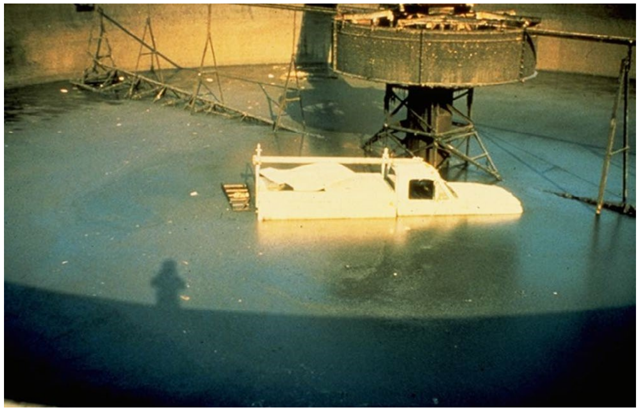
Executive Summary

- Wet weather events have a short duration and are infrequent. Risks tend to be acute, not chronic.
- Site specific variables result in site specific impacts and thus require site specific solutions.
- POTWs blended discharges may have a lesser impact than non-point source contributions.
- Reducing peak flows to POTWs to a level that allows for effective treatment by traditional biological processes alone may not always be practical.
- If needed, wet weather flows could be treated effectively by physical and/or chemical methods to address acute water quality concerns.

Wet-weather flows pose significantly different challenges to POTWs than normal



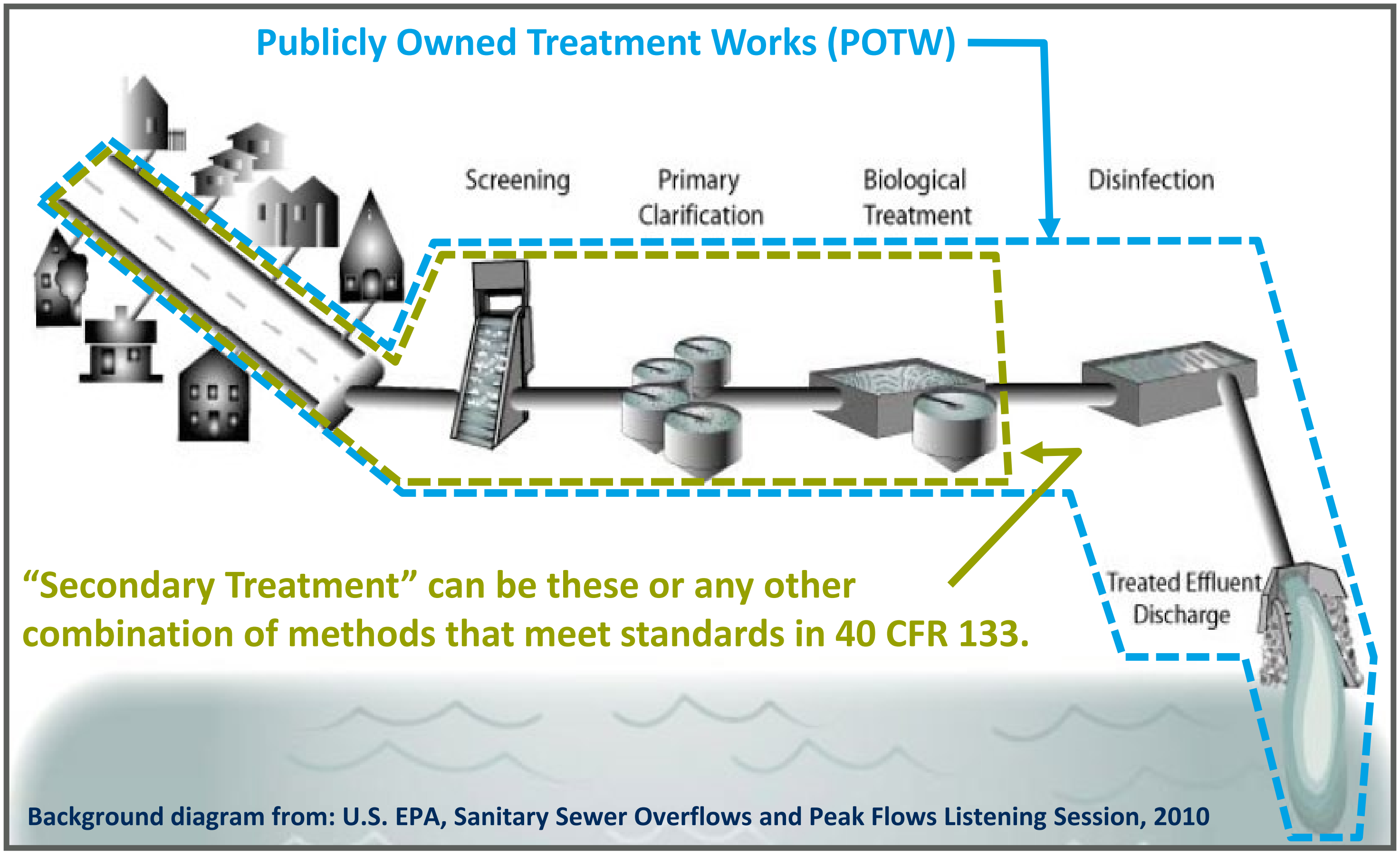




We have good answers for some of the challenges…but still working on others!

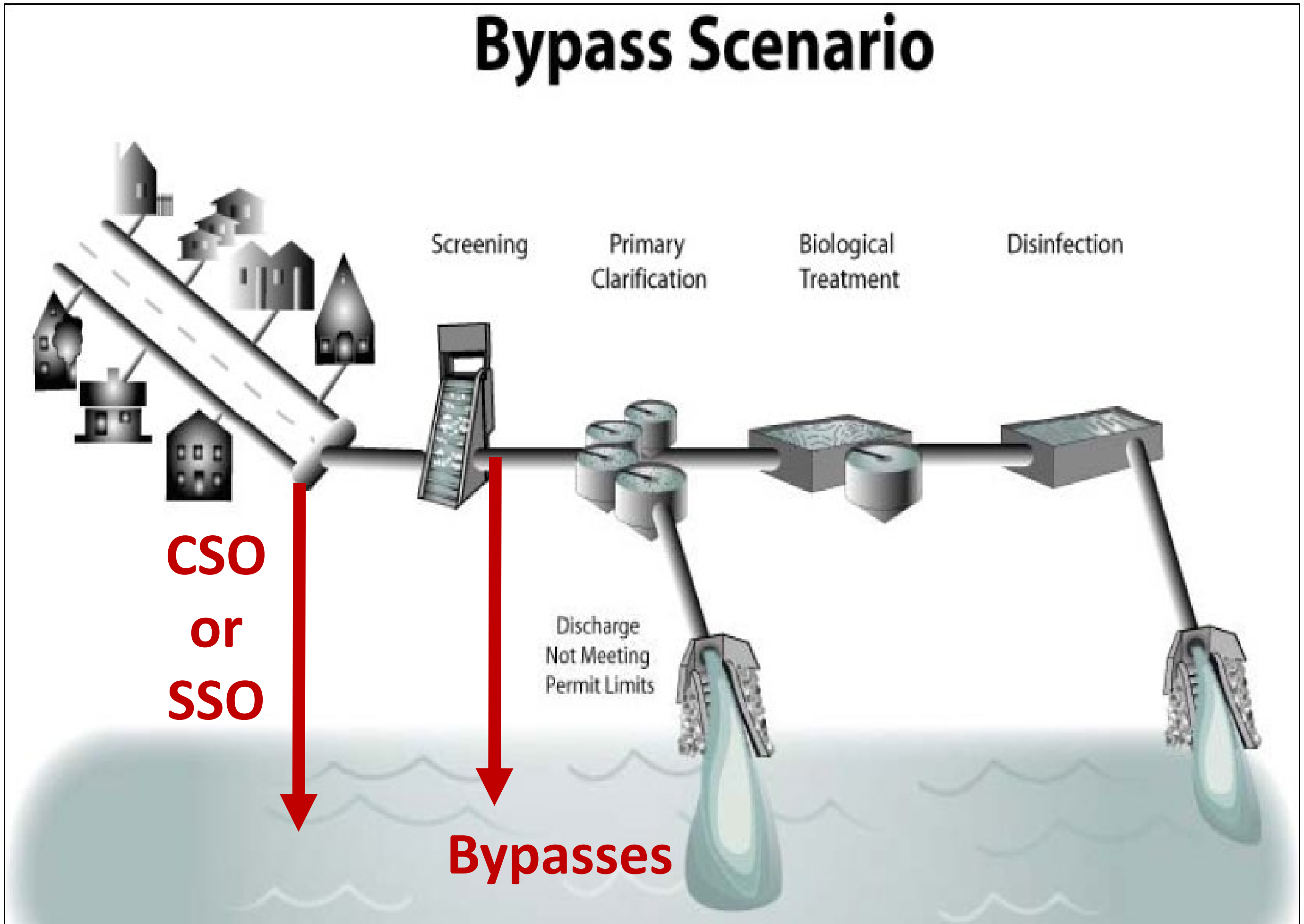
The challenge of managing wet weather flows in POTWs

To make sure we share the same language…



"Secondary Treatment" ≠ 100% biological treatment and doesn't have a precise scientific definition, especially for episodic wet-weather flows. Let's use scientific terms in this forum.

Blending ≠ overflows or bypasses



Background diagram from: U.S. EPA, Sanitary Sewer Overflows and Peak Flows Listening Session, 2010

This forum is focused on wet-weather flows received at the WRRF and blended with effluent from biological treatment processes. Not pictured here.

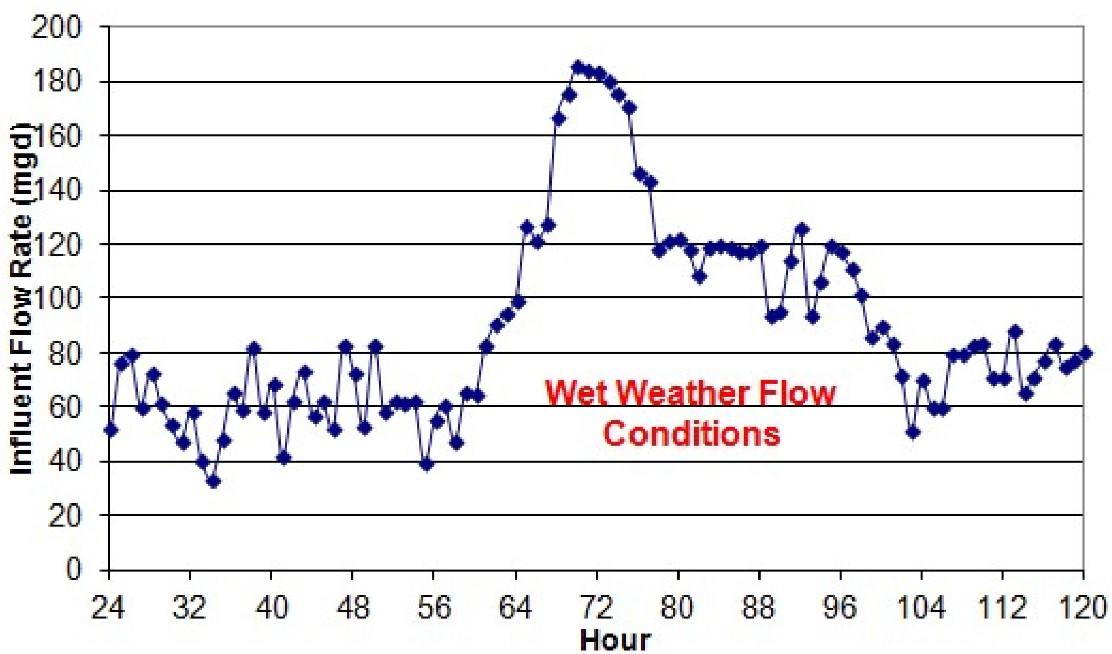
Compared to normal dry-weather challenges, wet-weather flows pose:

- **Receiving waters - significantly different set of drivers and risks**
  - Receiving stream flows >>7Q10 low-flow criteria
  - Focus of water quality concerns shift:
    - From chronic toxicity to acute toxicity
    - From chronic public health to acute public health
  - Point sources are a much smaller contributor than non-point sources in most watersheds. In many cases point sources may be negligible compared to stream background.
- **Influent characteristics - significantly different than normal design ranges**
- **More variability from POTW to POTW, no one-size-fits-all solutions**

The challenge of defining design influent flow rates…that change all the time!

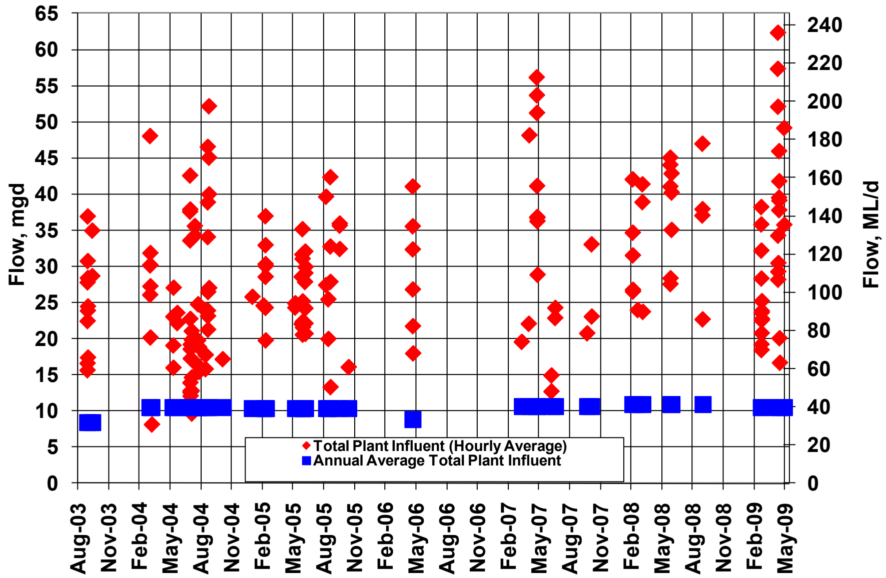
- In dry weather, flows and loads are predictable and somewhat "static"
- Wet weather flows and loads: unpredictable and "dynamic"

Example wet-weather hydrograph



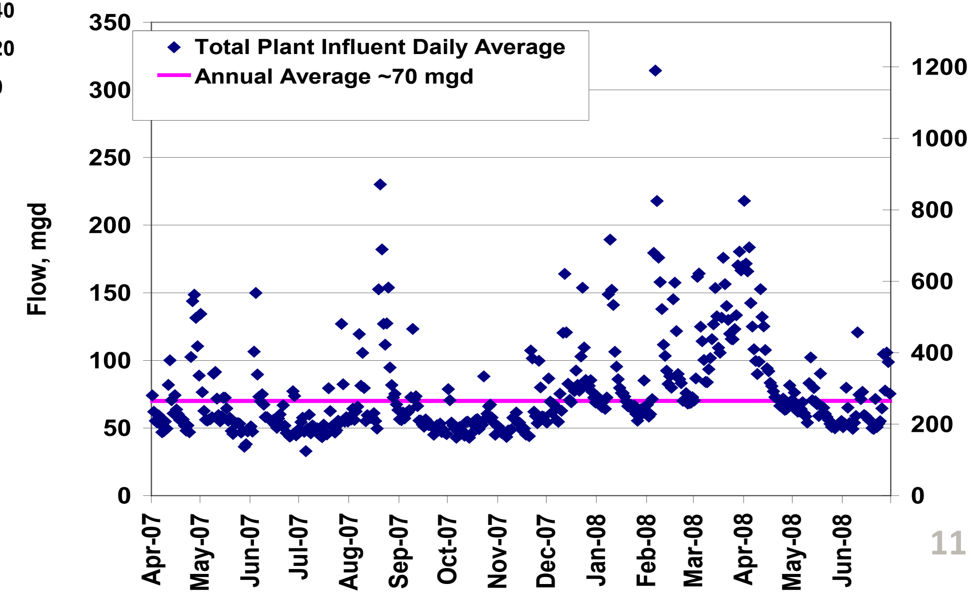
Wet weather flow rates peak much higher than conventional POTW design standards

LAWRENCE, KANSAS
WWTP WET-WEATHER INFLUENT FLOWS



- $Q_{PK} > 5Q_{AA}$ not unusual…
- …even with sustainable programs for inflow and infiltration reduction

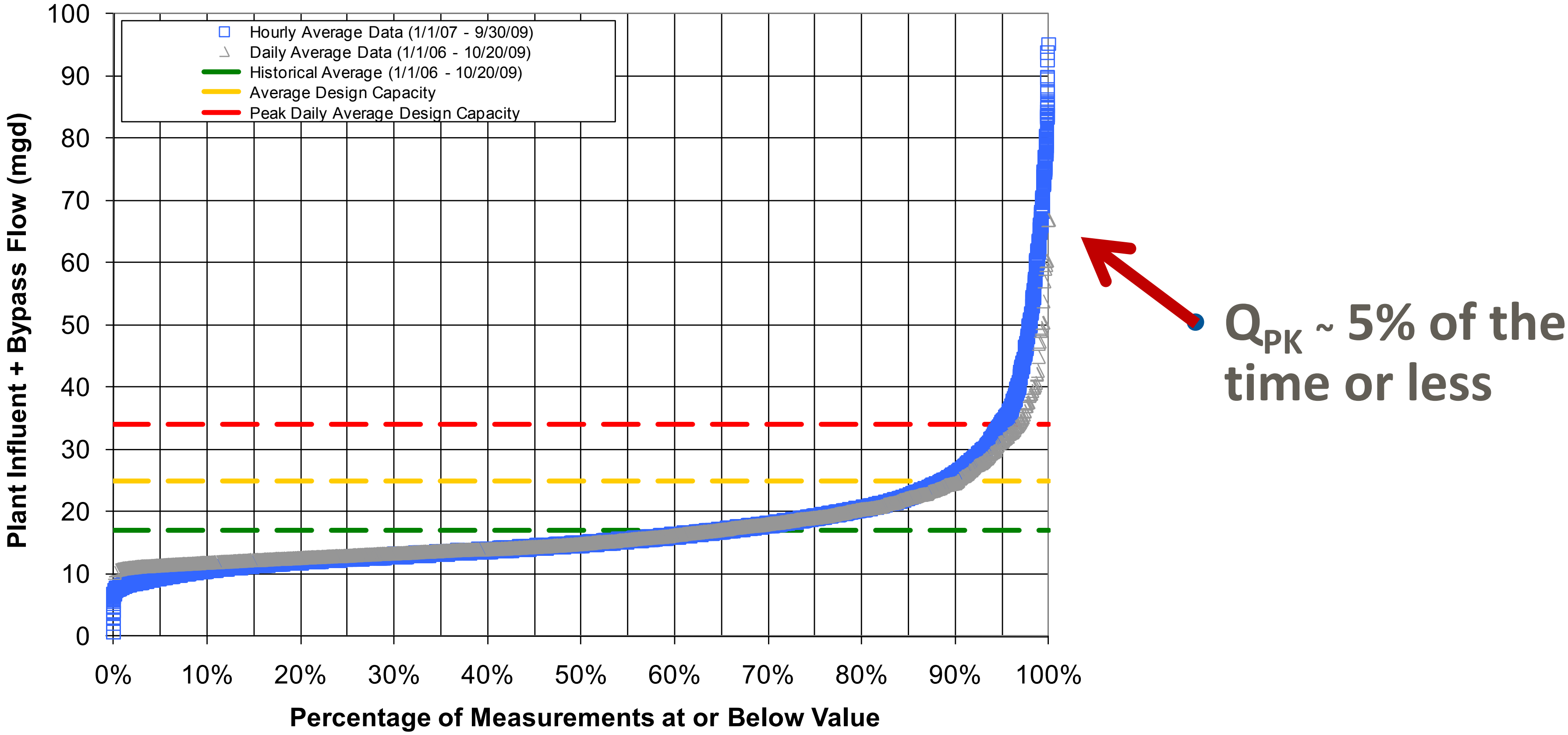
TOLEDO, OHIO
BAY VIEW WWTP WET-WEATHER INFLUENT FLOWS



Much higher than 2 to $3Q_{AA}$ in conventional POTW design standards (Ten States, WEF MOP 8, etc.)

Wet weather flows tend to be intermittent and short duration events

SPRINGFIELD, OHIO WWTP
INFLUENT FLOW PROBABILITY CURVE

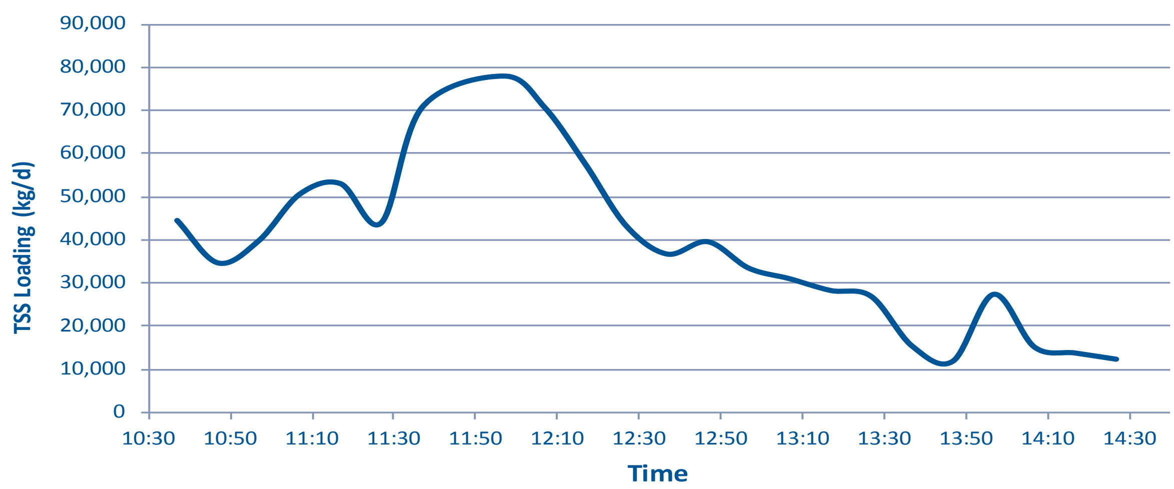


Peak wet-weather flows often considered "outliers" by POTW standards that optimize for continuous discharge

The challenge of defining design influent pollutant characteristics…also highly variable and unpredictable

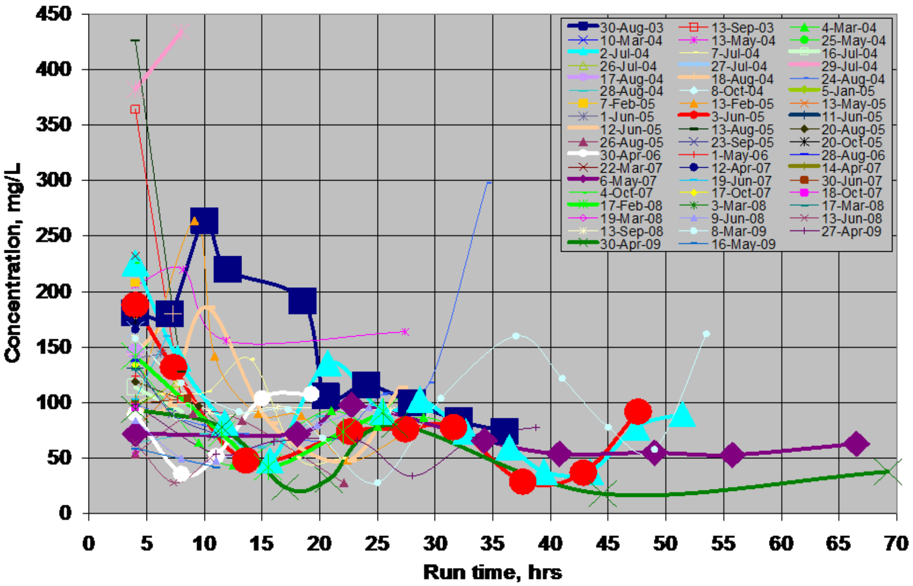
- Concentrations and loadings change <u>during</u> a storm…as well as <u>between</u> storms!
- First flush: How big? When does it occur? For how long?
- Highly dependent upon antecedent weather and soil conditions, design and operational details of collection system, condition of collection system, etc.

Example wet-weather pollutograph



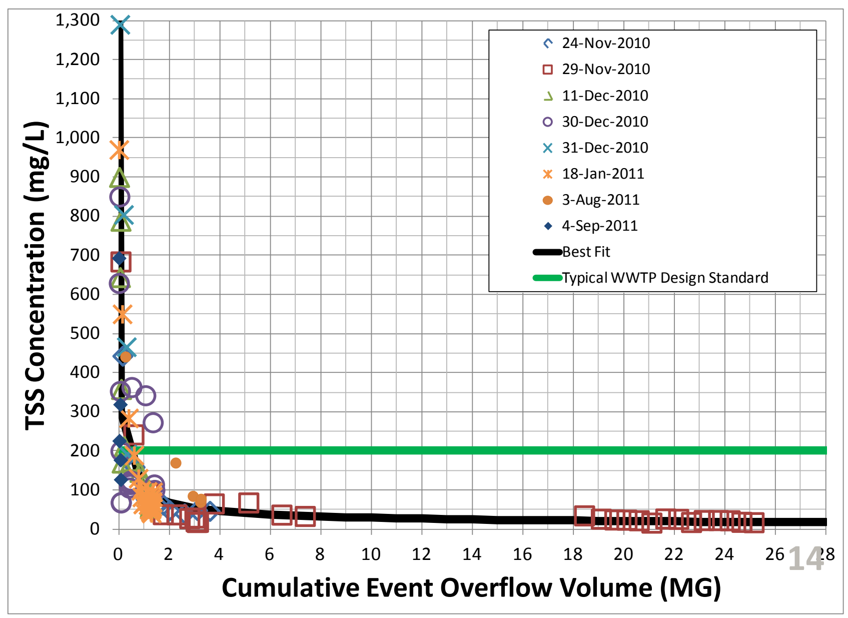
Wet weather flow influent concentrations tend to decrease rapidly after "first flush"

LAWRENCE, KANSAS
WET WEATHER EXCESS FLOW INFLUENT TSS



- $C \ll C_{AA}$ after first flush
- Similar for both combined and separate sewers

CINCINNATI, OHIO
CSO CHARACTERIZATION STUDY



First-flush dynamics are much different than conventional POTW diurnal design and operation standards

Challenges defining treatment objectives

- **Historically - Primary clarification equivalent + disinfection**
- **How best to define treatment objectives?**
  - Indicator concentrations in effluent?
  - Which indicator?
  - Water quality-based or technology-based effluent limits?
- **On what time basis?**
  - Event average?
  - Weekly average?
  - Monthly average?

A simple static number is not likely to be reasonable or defensible.

Challenge of rate-payer investments that are sustainable

- Life-cycle costs, benefits, and risks
- Asset management principles
- Appropriate levels of service
- Uncertain nature of wet-weather lends itself to probabilistic and risk-based planning and management
- Triple bottom line
- Sustainable return on investment

Knowing the true risks and benefits is the first step toward making sustainable investments

Historically, conventional POTW design and operating standards

- **Generally optimized for continuous collection, treatment and discharge**
- **Separate planning, standards and regulations have evolved for:**
  - POTW collection system
  - POTW treatment facilities
  - Separate stormwater systems

Optimal wet-weather solutions require:
•More holistic and integrated approach than dry-weather
•More POTW-specific considerations. One size doesn't fit all.

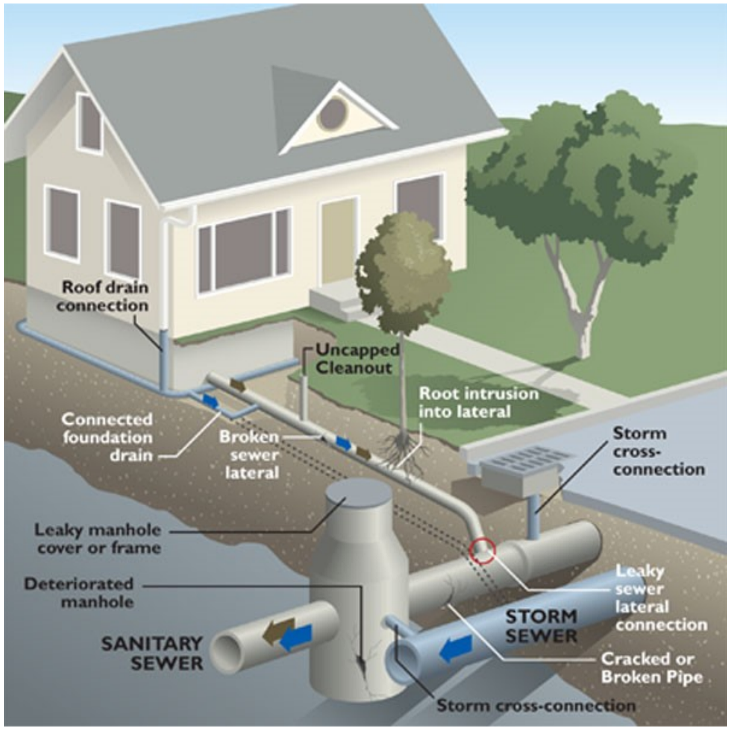
Wet weather flow management options

Sustainable solutions require holistic and long-term approaches

- **Goals**
  - Reduce risks from overflows
  - Protect water quality
- **Ongoing programs vs. "one & done" projects**
  - I/I reduction
  - Condition assessments
  - Operations & maintenance
  - Renewal & rehabilitation
  - Performance monitoring

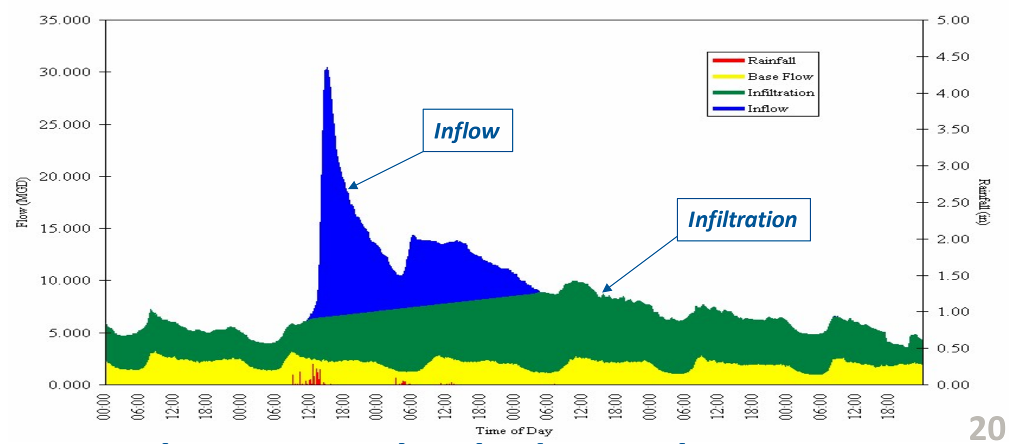
Integrated planning to evaluate and prioritize these + non-point source control measures on a watershed basis.

Reducing peak flows through I/I reduction



- **Are your long-term I/I reduction goals realistic?**
  - Old sewers leak…new sewers will leak when they get old
  - Private property and jurisdiction issues
    - Mains and manholes (public)
    - Satellite systems (multijurisdictional)
    - Service laterals (private)
    - Building I/I sources (private)

Different answers for each watershed. Pilot programs help determine cost and effectiveness of different I/I reduction measures.



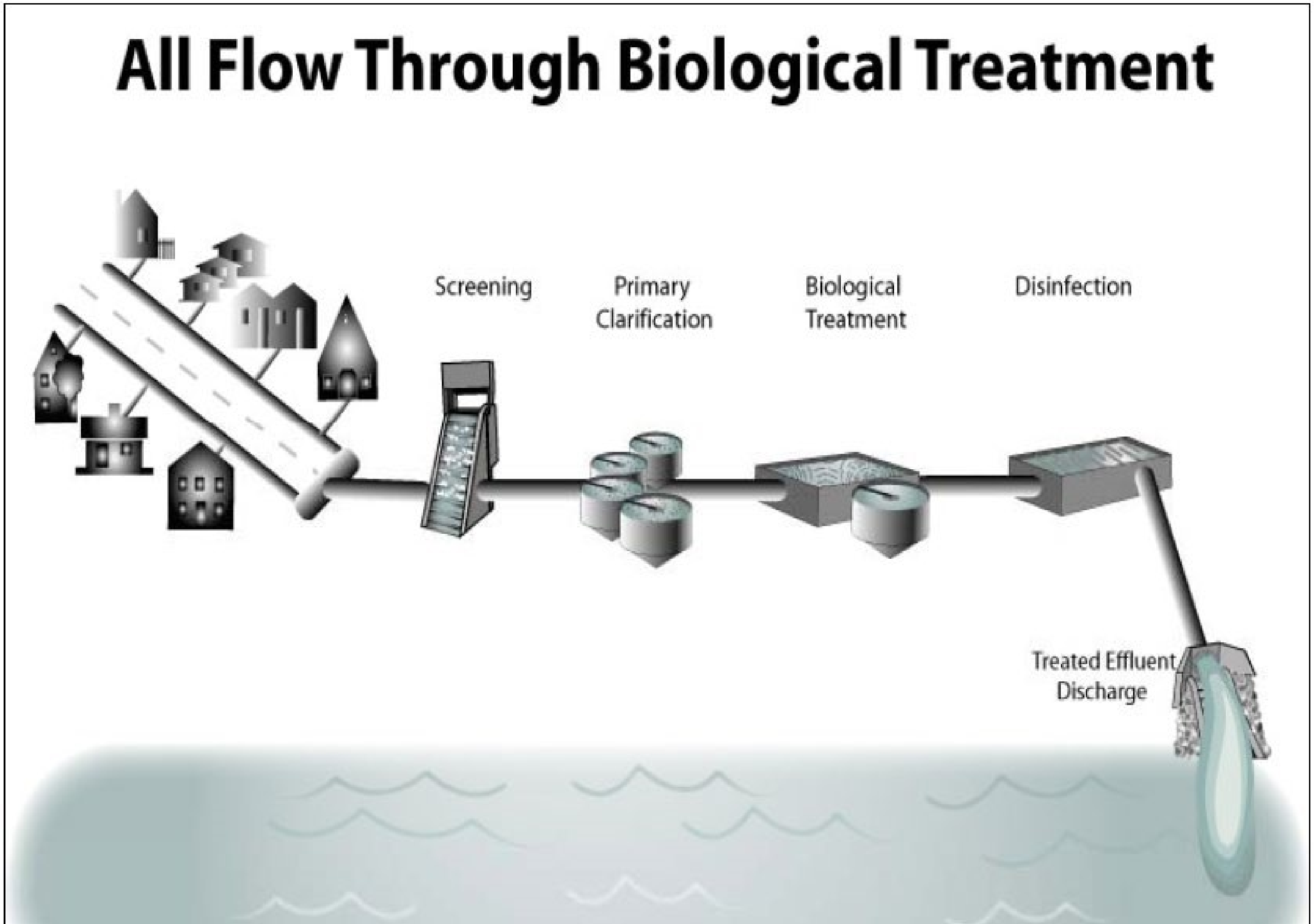
Example wet-weather hydrograph

Reducing peak flows through additional storage

- **Huge volumes required to eliminate overflows. Back-to-back storms and bigger storms than "design storm".**
- **May still need additional treatment capacity to handle storage dewatering rates.**
- **Too much storage may be more detrimental to environment.**
  - Stored wastes more difficult to treat than fresh wastes. Septicity and hydrolysis during storage.
  - Longer duration of wet-weather discharges when receiving stream flows have dropped and recreational use more likely.
  - Longer duration of dilute influent risks upset or inefficient biological treatment. Especially for biological nutrient removal.

Dynamic modeling and comprehensive analysis required to optimize storage and treatment sizing. Toledo case study.

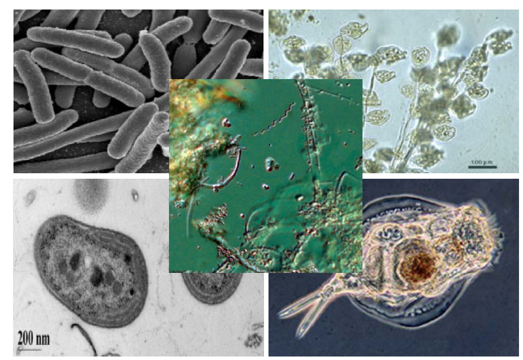
Maximizing use of existing treatment facilities



Background diagram from: U.S. EPA, Sanitary Sewer Overflows and Peak Flows Listening Session, June 30, 2010

Biological processes can handle some wet-weather flows, but have inherent risks and limitations

- Cold influent challenges - snowmelt, road salt
- **More biological equipment and infrastructure won't necessarily increase biological treatment**…biomass quantity and quality affect capacity.
- First-flush and dilution beyond range of conventional POTW design standards
- Protect your biomass
  - Critical dry-weather treatment component
  - Full recovery can take weeks
- Slow-growing nitrifiers, PAOs and higher life organisms for stable AS and BNR processes are particularly sensitive to wet-weather upsets



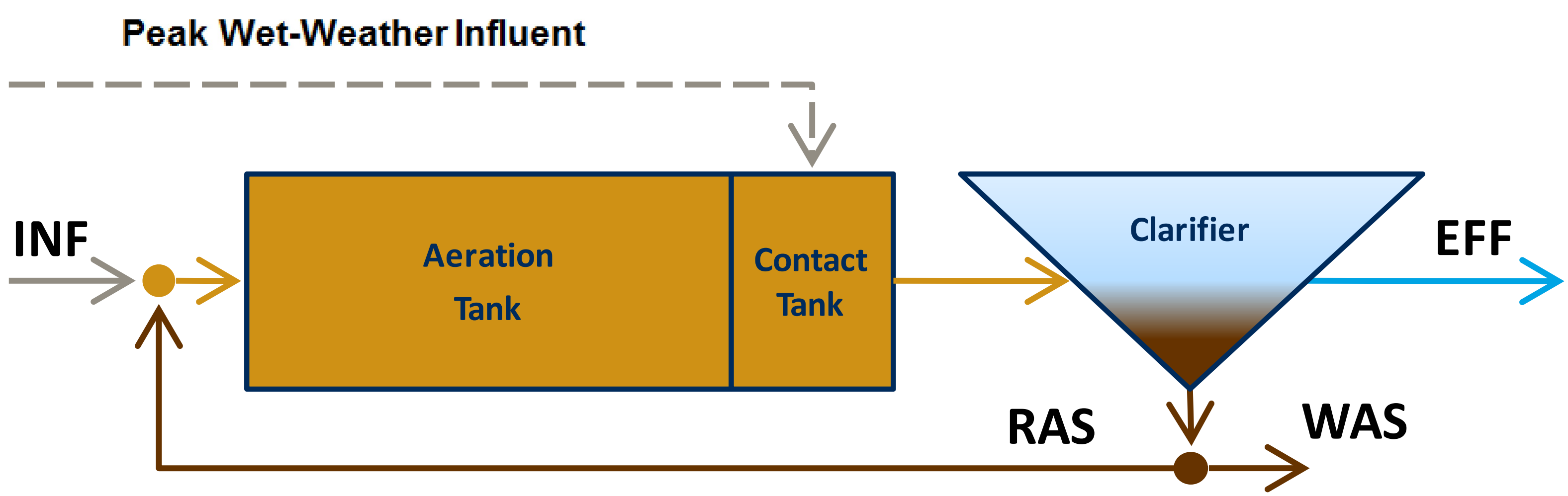
Don't Upset Your Good Bugs!

Some WRRFs may be able to temporarily reconfigure activated sludge trains to "weather the storm"

- Wet-weather step-feed or biomass transfer.
- Reconfigures AS to contact stabilization mode (a.k.a. "biocontact")
- Temporarily reduces clarifier solids loading rate
- Helps reduce washout potential

Does <u>not</u> increase biological degradation of wet-weather influent

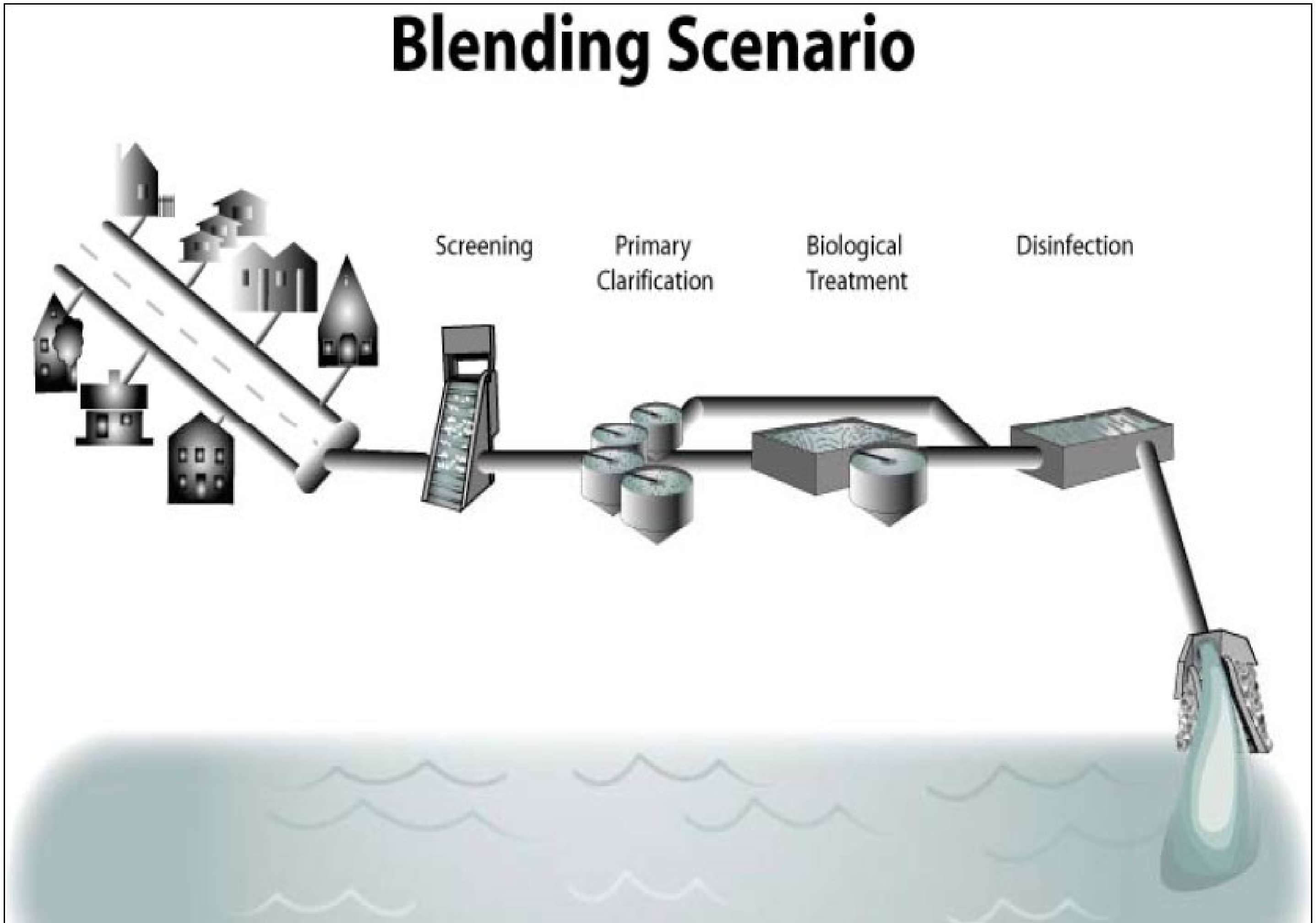
Temporary contact stabilization mode relies on physicochemical mechanisms



- Flocculation, adsorption and clarification mechanisms predominant activated sludge process under peak wet-weather flows.
- Minimal benefit from heterotrophic degradation, nitrification, denitrification, biological phosphorus removal during peak flows. Significant risk of biomass washout and upsets to these processes.
- Biological degradation of solids occurs after the peak flow passes.

Good solids/liquid separation is still the key

Wet-weather flow blending



Background diagram from: U.S. EPA, Sanitary Sewer Overflows and Peak Flows Listening Session, June 30, 2010

Effluent disinfection process and design depends upon water quality standards and other site-specifics

Providing auxiliary treatment capacity

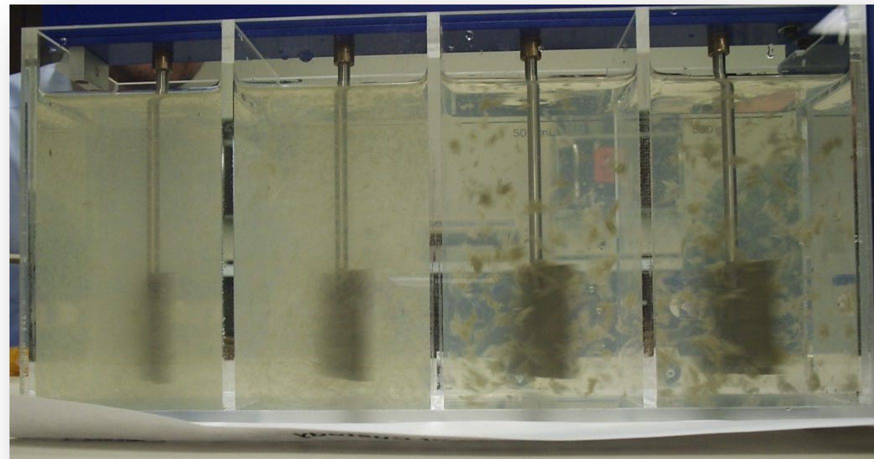
Background diagram from: U.S. EPA, Sanitary Sewer Overflows and Peak Flows Listening Session, June 30, 2010

Auxiliary treatment process and design depends upon disinfection requirements and other site-specifics

Effluent disinfection alternatives

- **Disinfection ≠ sterilization**
- **High-rate disinfection was one of five, high-priority technology categories to be verified under the EPA/NSF ETV Wet Weather Flow Technologies Pilot.**
  - Radiation - includes UV light, pulsed light, and other emerging electromagnetic processes. Currently, only UV technologies are viable.
  - *Chemical - include high-rate chemical disinfection by the use of chemical oxidants (e.g., chlorine, bromine, chlorine dioxide, ozone, peracetic acid, peroxide, etc.)*
  - Mixing - which is relevant to high-rate chemical disinfection includes inductive mixers and diffusers.

Efficacy of ANY disinfection system depends on effluent quality



- **UV disinfection**
  - TSS concentration
  - Particle size distribution
  - UV transmittance
- **Chemical oxidants**
  - Overcoming competing oxidant demands (COD – not BOD)
  - Process control (e.g., chloramination versus free chlorination)
  - Residual oxidant management challenges including TRC/TRO limits and dechlorination/quenching, disinfection by-products, whole effluent toxicity (WET)
- **Design of disinfection system requires knowledge of: target organism, inactivation rate (N/N_0) and WQ**

Many studies focus on disinfection of indicator organisms in wet weather flows

Disinfectant doses required to meet 2002 U.S. EPA criteria for illness rate of 14 illnesses per 1,000 people in CSOs (Moffa et al., 2005)

Indicator Organism	5-min Chlorination	5-min Chlorine Dioxide	3-min Ozonation	5-sec UV
Fecal coliform	18 mg/L	6.3 mg/L	25 mg/L	110 mJ/cm^2
E. coli	18 mg/L	6.6 mg/L	23 mg/L	100 mJ/cm^2
Enterococcus spp.	22 mg/L	8.6 mg/L	20 mg/L	140 mJ/cm^2

- A few studies have focused on **pathogen** removal performance of wet-weather flows
- A few studies have used site-specific pathogen data for development of human health risk assessments

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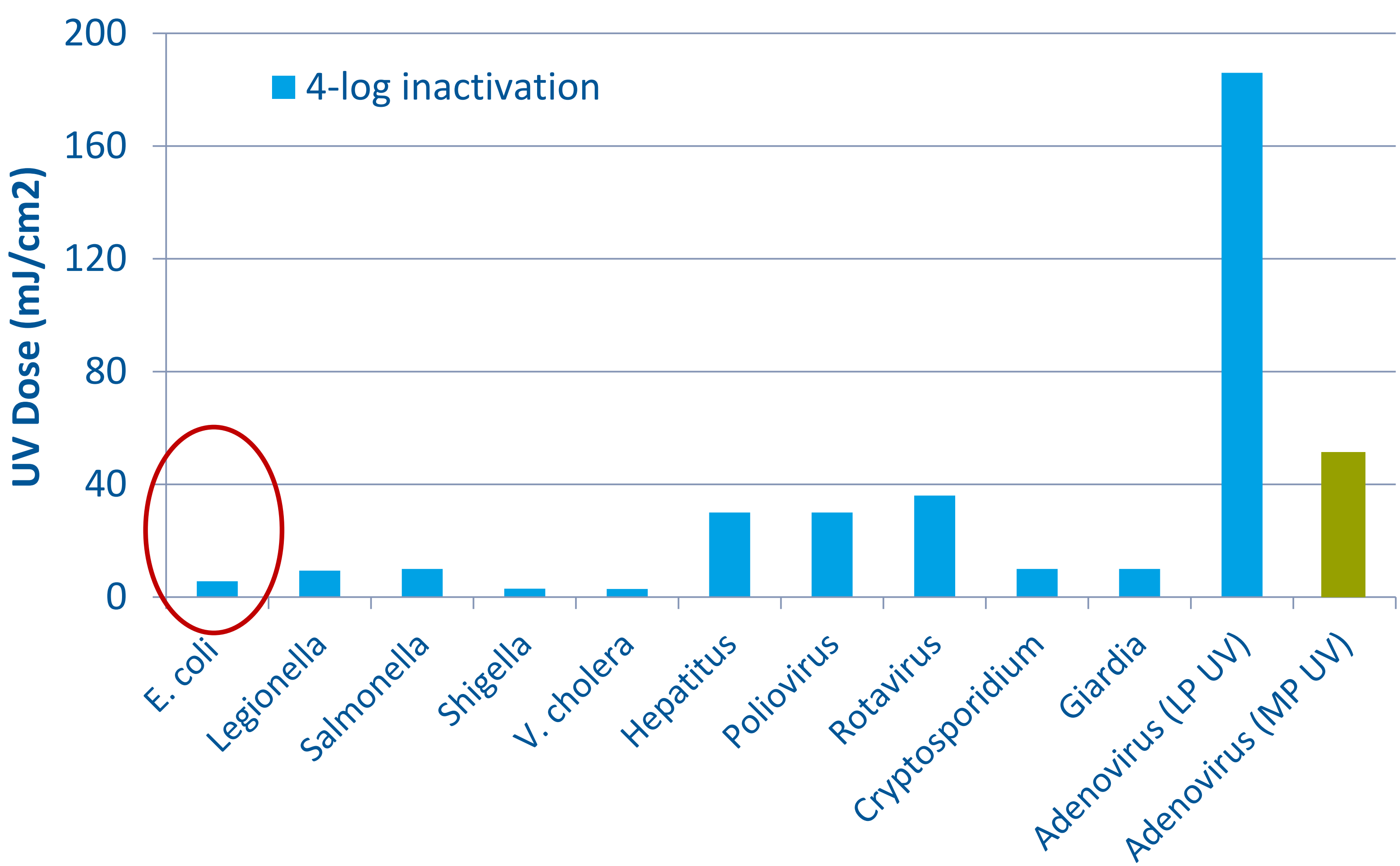
We are designing disinfection systems and are complying with indicator organisms…



Engineering challenges of disinfection are NOT inactivating indicator organisms…

Chlorine CT values (mg*min/L) for pathogens at 20C

Inactivation Rate	Free Chorine at pH 7.5	Chloramines at pH 8
Giardia cysts (EPA Disinfection Profiling and Benchmarking Guidance Manual, 1999)		
2-log	33	735
3-log	37	1100
Viruses (Keegan, et al., 2012; Black, 2009 and Sirikanchana, 2008)		
2-log	10	2318
3-log	13	3141
4-log	16	3965
E. coli (Taylor et al., 2000)		
3-log	0.09	73

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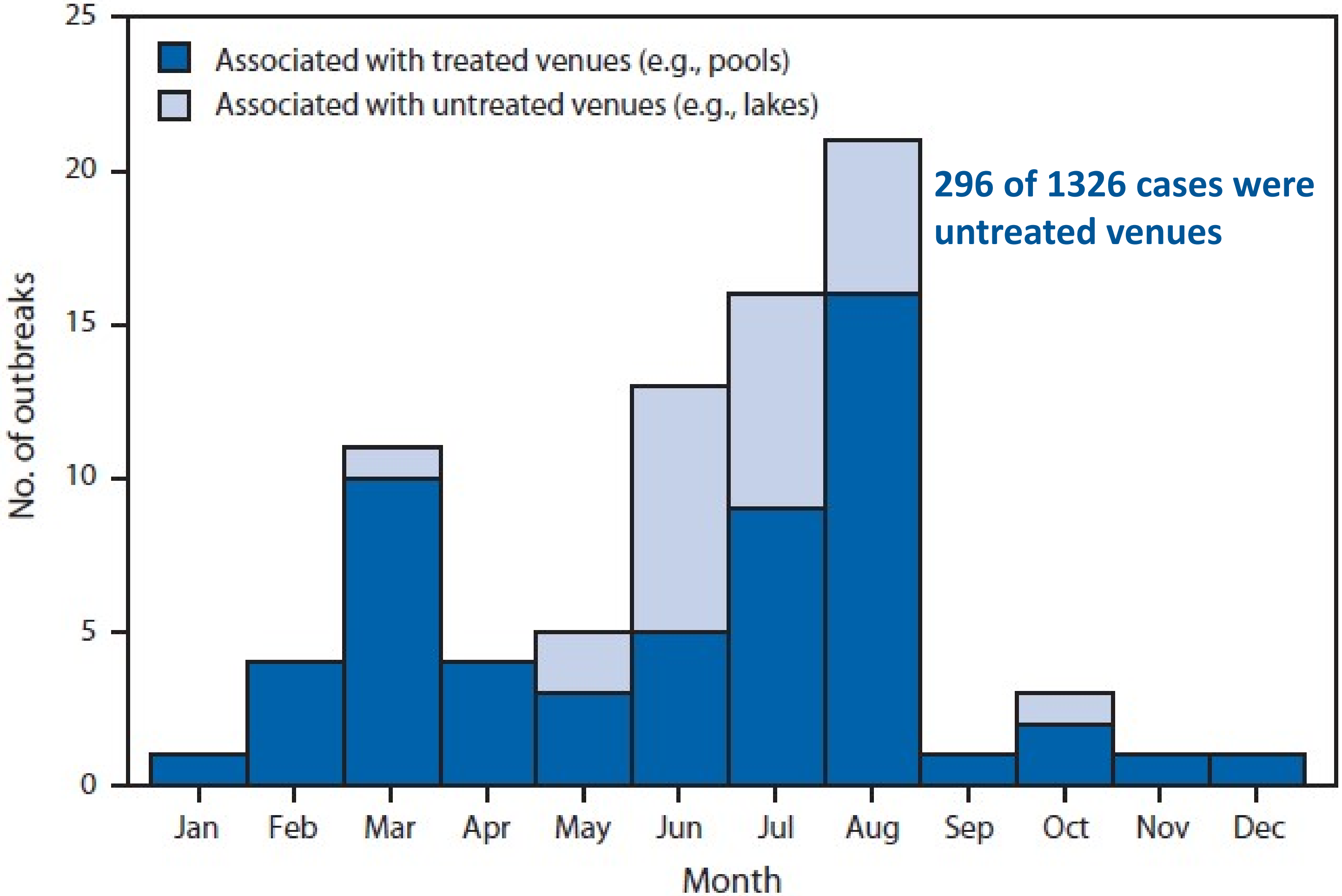
CDC report (2009 – 10) indicates about half of the outbreaks were associated with cyanobacteria toxins



Pathogen and risk characterization of wet weather flows

- *"Dry and wet weather risk assessment of human health impacts of disinfection versus no disinfection in the CAWS"* (Geosyntec, 2008)
- Risks < 8 - 14 illnesses/1000 exposures (EPA guidelines in RWQC)
- **Pathogens in waterway are attributed to non-WRP sources**

Total Expected Primary Illnesses per 1,000 Exposures under Combined Dry and Wet Weather Using Different Effluent Disinfection Techniques

Exposure Input	Waterway		
	North Side	Stickney	Calumet
Dry Weather	0.36	1.28	0.10
Wet Weather	2.78	2.34	0.36
Combined Weather Samples	1.55	1.77	0.21

Note:
Includes all primary gastrointestinal illnesses from *E. coli*, *Salmonella*, total enteric viruses, adenoviruses, *Giardia*, and *Cryptosporidium* expected from the waterway exposures. Waterway concentration inputs for the simulations were randomly selected (bootstrap sampled) from datasets that include the indicated sample sets.

Pathogen characterization of wet weather flows - impact of blending

- ***"Impact of Wet-Weather Peak Flow Blending on Disinfection and Treatment: A Case Study at Three WWTPs"* (Rukovets and Mitchell, 2010)**
  - Pathogen removal is site specific; depends on operations
  - TSS and some pathogen/indicator concentrations are higher during blending, compared to dry weather events
  - Microorganisms (indicators) are associated with TSS
  - No risk assessment conducted in this study
- ***"Characterizing the quality of effluent and other contributory sources during wet weather events"* (Gray et al., 2009)**
  - The study also addresses risk assessment

Microbial characterization of wet weather flows - impact of auxiliary treatment

- ***Disinfection efficacy depends on effluent WQ and providing auxiliary treatment demonstrates substantial benefits with respect to disinfection of indicators/pathogens***
  - Lawrence, KS study; HRT performance is indistinguishable from main process (bacteria)
  - Akron, OH study; EHRT provides removal of pathogens, and disinfection on EHRT effluent is more efficient for bacteria
  - City of Toledo, OH study; high rate treatment provided better microbial removal than AS, no difference after disinfection
  - Many others…
  - **Auxiliary treatment and disinfection provides microbial quality indistinguishable from main treatment process**

Auxiliary treatment with equivalent of primary clarification

- **Conventional standard = primary clarification + effluent disinfection**
  - Standard technology assumption for blending
  - Decades of full-scale operations
  - Long understood by water quality profession to support CWA and codified secondary treatment requirements, when operated in parallel with biological treatment
  - Presumption Approach of USEPA 1994 CSO Control Policy

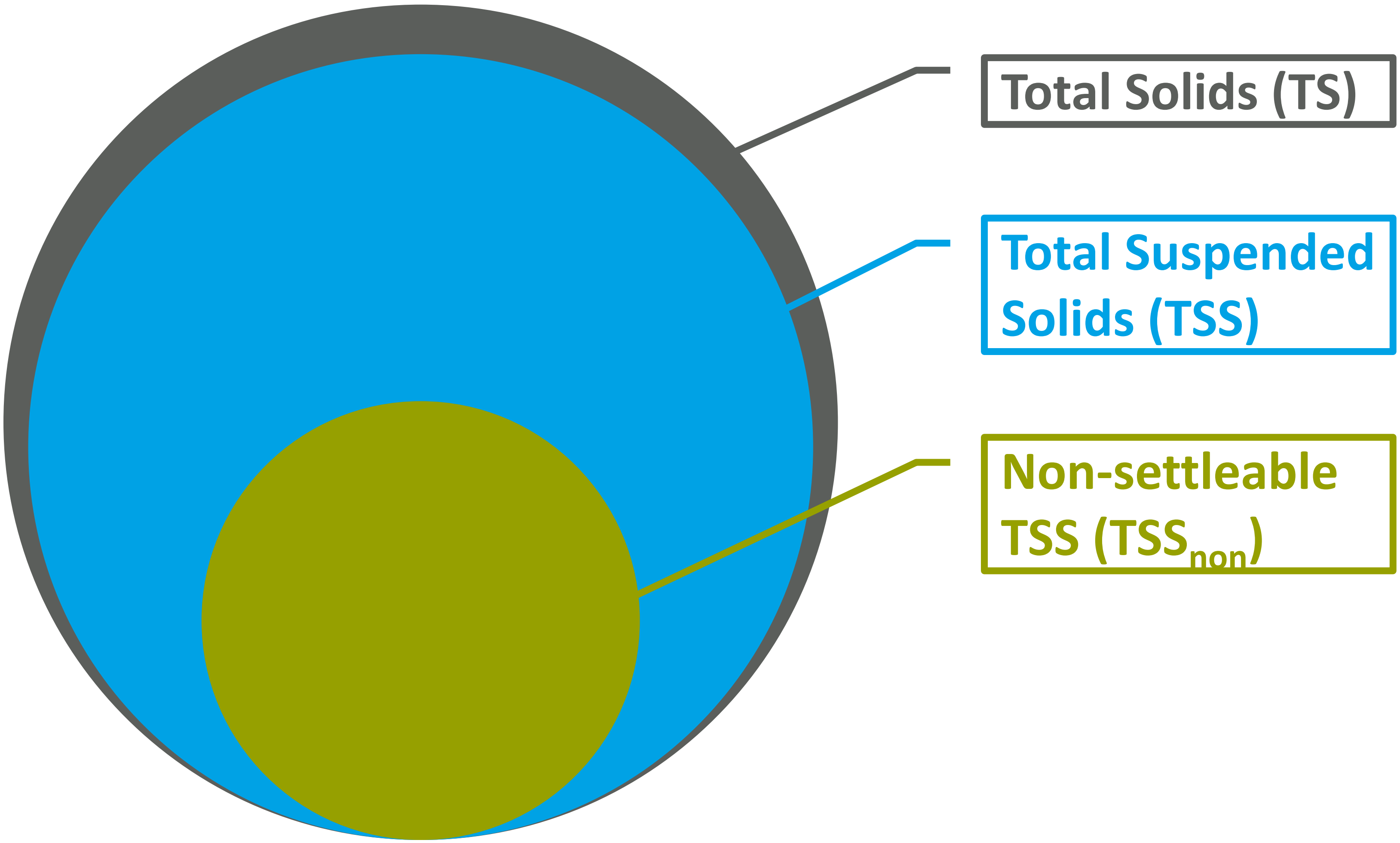
Clarification alternatives

Sedimentation	Filtration	Flotation
1. Conventional Clarifier	1. Shallow Granular Media (Sand, Anthracite, etc.)	1. Dissolved Air Flotation (DAF)
2. Vortex Separators (Swirl Concentrators)	2. Deep Granular Media (Sand, Anthracite, etc.)	
3. Lamella Settlers	3. Microscreens	
4. Chemically Enhanced Sedimentation	4. Floating Media	
a. Conventional Clarifier	5. Cloth Media	
b. Lamella Settler	6. Compressible Media -Fuzzy Filter™, FlexFilter™	
c. Solids Contact / Sludge Recirculation - DensaDeg®, CONTRAFAST®		
d. Microsand Ballasted Flocculation - ACTIFLO®, RapiSand™		
e. Magnetite Ballasted Flocculation -CoMag™		

High-Rate Treatment (HRT)

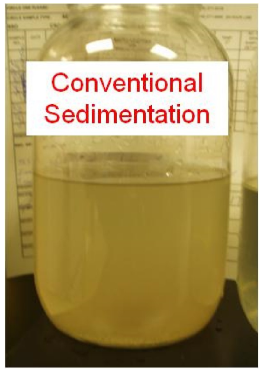
Enhanced HRT (EHRT)

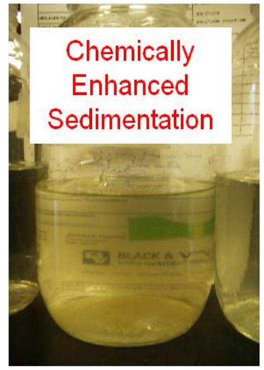
Understanding disinfection requirements and influent solids are keys to successful treatment of wet-weather flows

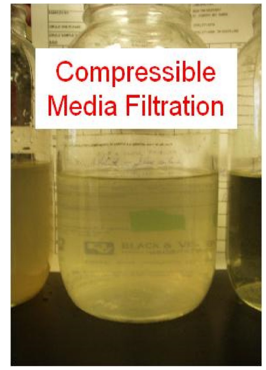


EHRT alternatives focus on removing TSS_{non}

Summary of clarification technologies







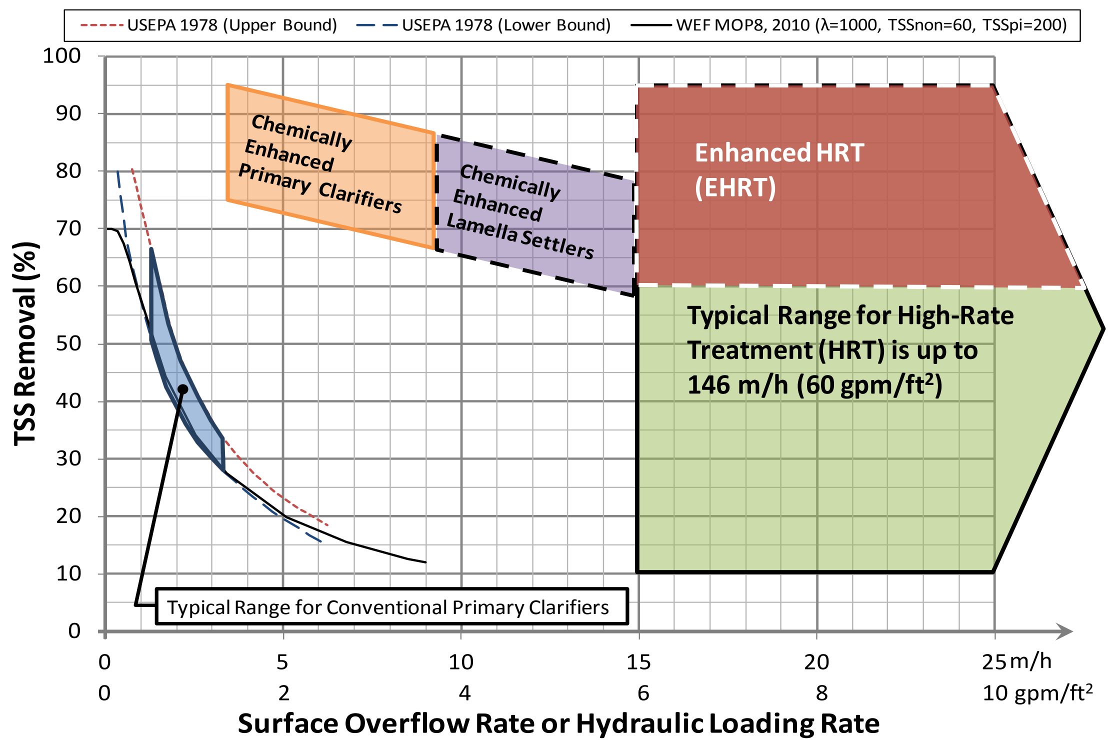


Figure 14.1 from *Wet Weather Design and Operation in Water Resource Recovery Facilities*, pending 2014 publication by WEF

Starting to see some stormwater treatment with HRT and EHRT

- **Stormwater applications include:**
  - Vortex separators and screens for settleables and floatables
  - Chitosan enhanced sand filters treating stormwater runoff from North Boeing Field, Seattle, WA
  - CMF + UV stormwater BMP treating Weracoba Creek in Columbus, GA since 2007
- **Can or should auxiliary treatment facilities also be used for stormwater treatment to provide higher level of pollutant removal than no stormwater treatment?**
- **Can or should controlled discharges of stormwater be allowed to help maintain sewers? Solids flushing, decreased odors and corrosion.**

**Innovative use of existing infrastructure.
Maximize use of WRRF capacity.**

Recent case studies of wet weather flow management

We only have time now for a few, but data on blending also includes:

- Blending practiced in the U.S. ever since biological treatment became standard for dry-weather flows. DMRs record effluent monitoring results for indicator bacteria.
- What about blending practiced by WWTPs outside the U.S.? Europe, New Zealand, Australia, others?
- Draft *Summary of Blending Practices and the Discharge of Pollutants for Different Blending Scenarios* (USEPA/Tetra Tech, 2014)

Data on receiving water quality and non-point source contributions during wet-weather discharges is more scarce.

Gray *et al.* (2009)

EAST BAY MUNICIPAL UTILITY DISTRICT

WATER ENVIRONMENT RESEARCH FOUNDATION

Wet Weather Effluent Blending Project

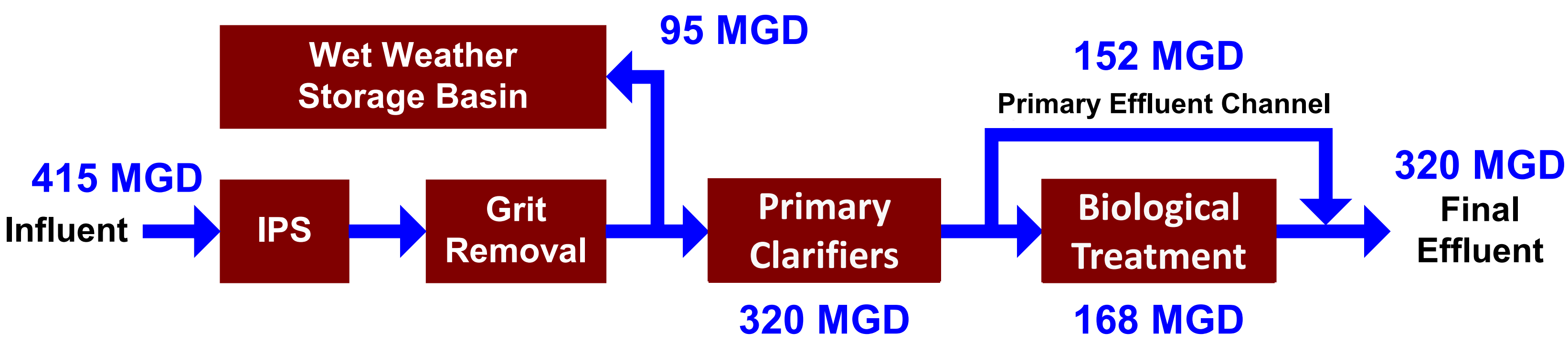
WERF Project No. 03-CTS-12PP

EBMUD Main Wastewater Treatment Plant

Blending at the EBMUD Main WWTP

EBMUD

EBMUD Main WWTP Blending at Peak Flow = 415 MGD



Project Approach

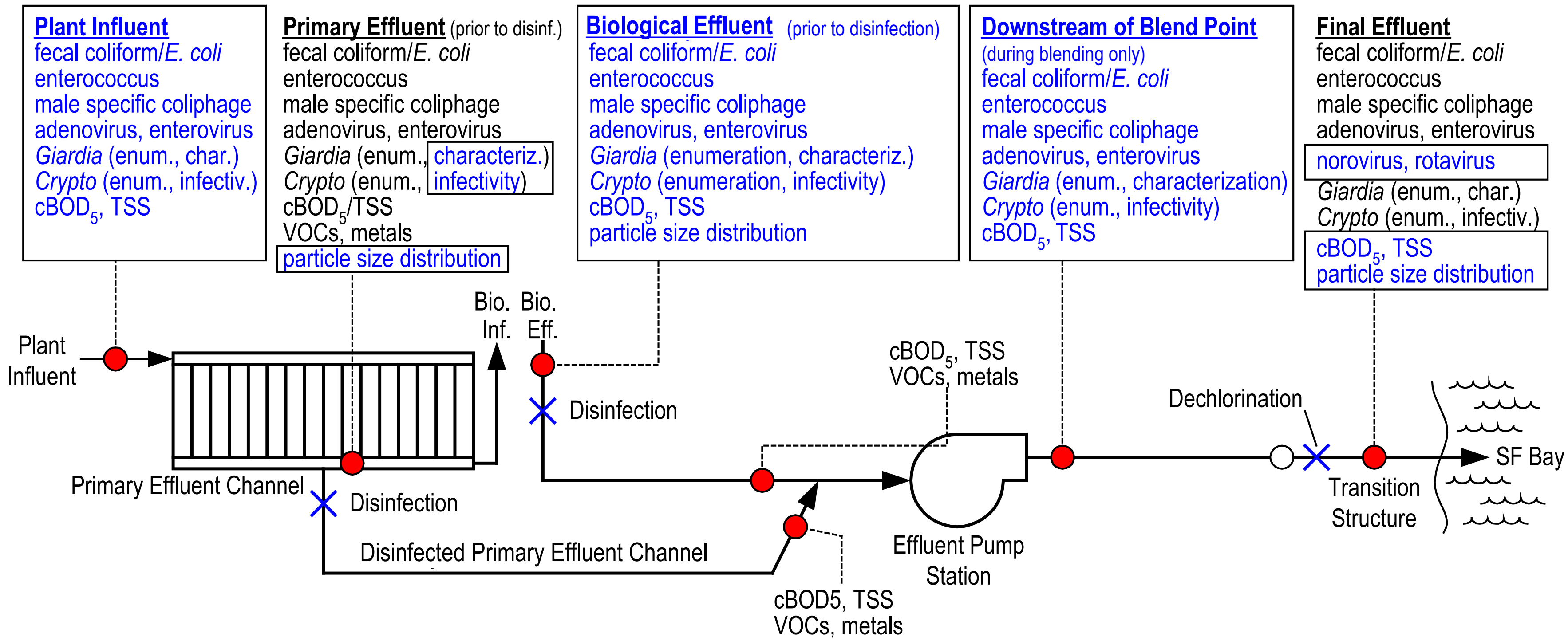
- **Conduct field sampling** compare final effluent and receiving water quality during blending to baseline conditions through field sampling — dry weather and wet weather non-blending (*i.e.*, peak biological treatment)
- **Use computer model** to estimate pathogen and indicator organism concentrations in SF Bay under wet weather non-blending and blending scenarios
- **Estimate incremental risk** to public health, if any, attributable to blending practices
- Evaluate alternatives to blending practices and estimate incremental benefits to public health
- Prepare a guidance manual to assist other interested parties in conducting similar evaluations in their own area

Field Sampling Locations and Analysis

- Primary effluent, Final effluent – single grabs
  - *Giardia, Cryptosporidium*
  - Adenovirus, Enterovirus
  - Fecal coliform, *E. coli*, enterococcus, male specific coliphage
  - $cBOD_5$, TSS, VOCs, metals
- San Francisco Bay (3 locations)
  - Fecal coliform, *E. coli*, enterococcus, male specific coliphage
  - Limited *Giardia* and *Cryptosporidium* testing

In-plant Field Sampling Locations and Analysis at EBMUD MWWTP

Grab samples



-**Blue highlights were added from Year 2 Field Sampling (EPA Phase II Funding)**

-**VOCs (Volatile Organic Compounds)**

-**TSS (Total Suspended Solids)**

-**$cBOD_5$ (5-day Carbonaceous Biochemical Oxygen Demand)**

-**SF Bay (San Francisco Bay)**

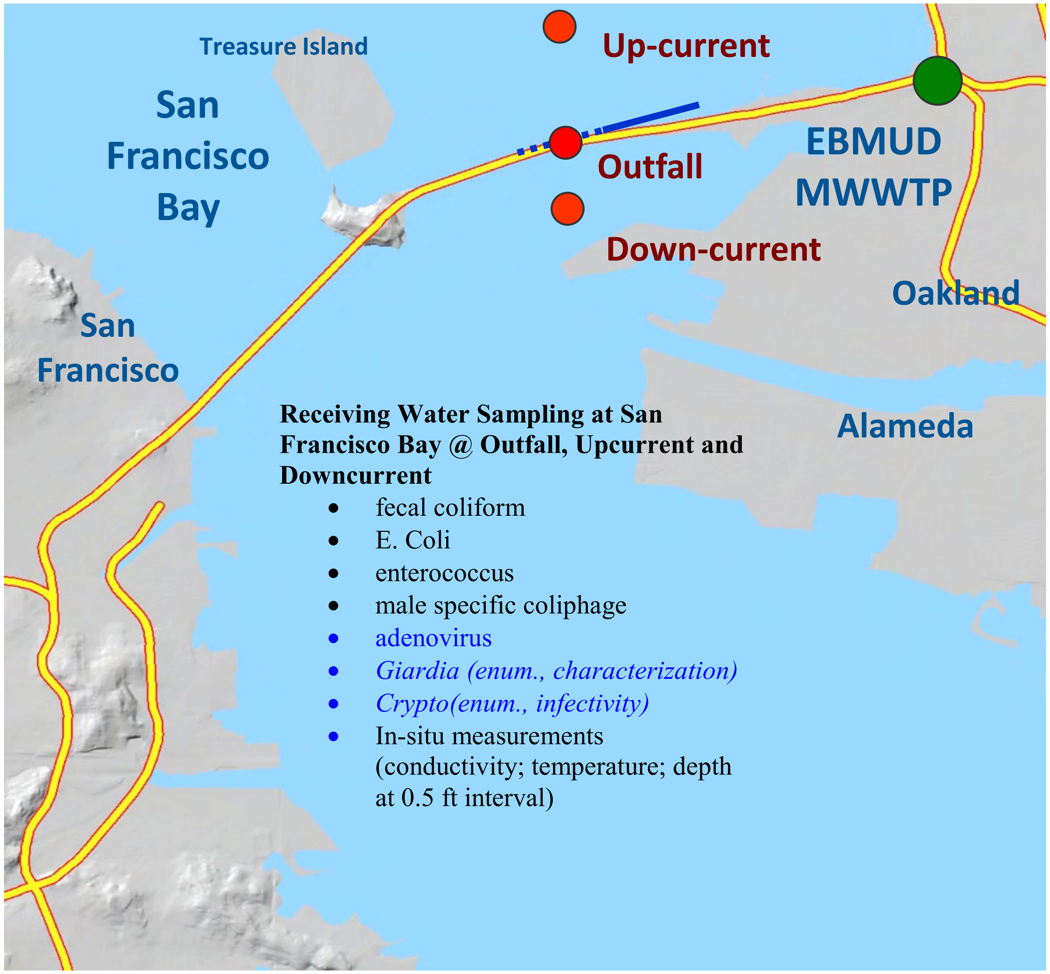
Field Sampling Events

- Completed 3 years field sampling, data allowed direct comparison of blending to baseline conditions — dry weather and wet weather non-blending

Facility (Field Test Site)	Collection System	Field Sampling Events Completed												Total
		Dry Weather				Wet Weather Non-blending				Blending				
		Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3	Total	
EBMUD MWWTP	SSS	**1**	**1**	**--**	**2**	**2**	**2**	**3**	**7**	**4**	**1**	**2***	**7**	16
CCSF SEWPCP	CSS	**1**	**--**	**--**	**1**	**1**	**--**	**--**	**1**	**5**	**--**	**--**	**5**	7
MMSD JIWWTP	CSS	**--**	**--**	**--**	**--**	**--**	**0**	**1**	**1**	**--**	**0**	**1**	**1**	2
E/S WPCF	SSS	**--**	**--**	**--**	**--**	**--**	**1**	**1**	**2**	**--**	**0**	**0**	**0**	2
	Total	**2**	**1**	**--**	**3**	**3**	**3**	**5**	**11**	**9**	**1**	**3**	**13**	27

Receiving Water Sampling at San Francisco Bay for EBMUD MWWTP

- Three Sampling Locations
  - **Outfall (midpoint of diffuser section)**
  - **One nautical mile “Up-current”**
  - **1/2 nautical mile “Down-current”**
- Up-current and down-current locations are dependent on tide direction
- Grab samples at each location during each sampling event



EBMUD Field Sampling Event Details

Year	Event No.	Event Type	Date	Plant Flow Rates (MGD) Influent	Primary Effluent	Biological Effluent	Blend Ratio*	%Primary Effluent
1	1	DW No. 1	9/21/05	65	0	65	--	0
	2	WW Non-blend No. 1	1/14/06	135	0	135	--	0
	3	WW Non-blend No. 2	2/27/06	135	0	135	--	0
	4	Blend No. 1	3/6/06	210	42	168	0.25	20%
	5	Blend No. 2	3/25/06	215	65	150	0.43	30%
	6	Blend No. 3	3/29/06	180	30	150	0.20	17%
	7	Blend No. 4	4/3/06	200	40	160	0.25	20%
2	8	DW No. 2	12/4/06	65	0	65	--	0
	9	Blend No. 5	12/12/06	235	67	168	0.40	29%
	10	WW Non-blend No. 3	2/9/07	150	0	150	--	0
	11	WW Non-blend No. 4	2/10/07	168	0	168	--	0
3	12	WW Non-blend No. 5	12/20/07	170	0	170	--	0%
	13	Blend No. 6 (in-plant)	1/4/08	302	132	170	0.78	44%
	14	Blend No. 7 (in-plant)	1/25/08	286	118	168	0.70	41%
	15	WW Non-blend No. 6	1/26/08	164	0	164	--	0%
	16	WW Non-blend No. 7	2/1/08	144	0	144	--	0%

DW = dry weather WW = wet weather

*** Blend Ratio = Ratio of Primary Effluent Flow (MGD) to Biological Effluent Flow (MGD)**

Field Sampling Results at EBMUD MWWTP

EBMUD

Results similar between blending and non-blending events for Final Effluent

- *Crypto and Crypto Infective*
- *Enterovirus, Rotavirus*
- *Fecal Coliform, E. Coli, Enterococcus, Male Specific Coliphage*
- *Volatile organic compounds*
- *Metals (calculated conc. for blending events all below NPDES permit requirement)*

Results higher during blending compared to non-blending events for Final Effluent

- *Giardia Enumeration by ~ One Order of Magnitude*
- *Adenovirus (difference is not statistically significant)*
- *Norovirus GI and GII (non-quantitative, inconclusive)*
- *$cBOD_5$ (33, 38 and 43 mg/L) and TSS (60, 62, and 89 mg/L) during blending events vs. less than 20 mg/L for non-blending events*

Modeling Scenario

EBMUD

Modeling Period: Dec 1, 2005 to Jan 4, 2006, a 35–day period

San Francisco Bay Modeling: Simulate relative water quality impacts of MWWTP blending practices on receiving water quality at the San Francisco Bay

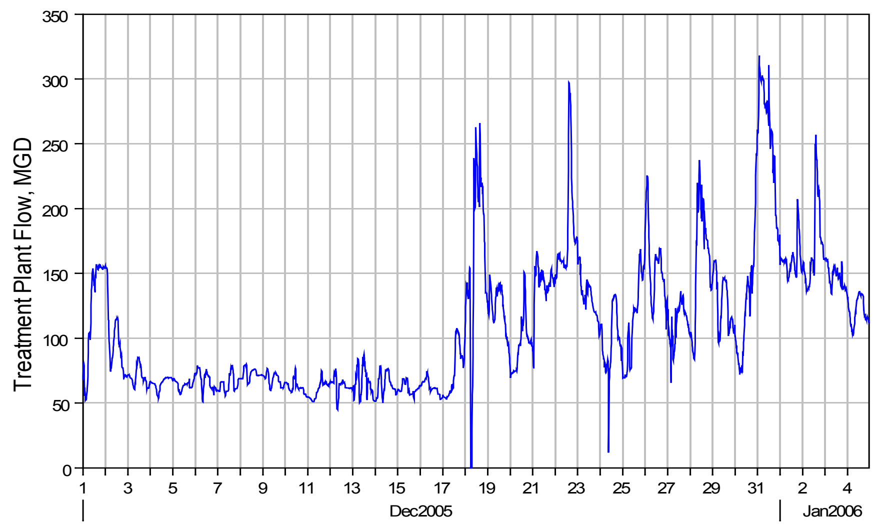
Modeling Scenario	Modeling Flow	Input Pathogen Concentration for Bay Modeling (based on 3-yr field sampling)		Pathogen Exponential Die-off Rate for Bay Modeling(1)	Bay Model Output
		Non-blending	Blending		
Worst Case	**Actual MWWTP final effluent flow rate (in 15-min interval)**	**Average conc. of non-blending events**	**2nd highest conc. measured for blending events**	**Lowest die-off rate based on literature review for seawater within the temperature range of 8 - 18 ^{0}C(2)** ***Giardia*: K = 0.45 day^{-1}** ***Adenovirus:* K = 0.054 day^{-1} (T_{99} = 85 days)**	**Simulated pathogen concentration for that 35-day period in 15-min interval at any location in San Francisco Bay**
Geometric Mean Case	**Same as above**	**Geometric mean conc. of non-blending events**	**Geometric mean conc. of blending events**	**Same as above**	**Same as above**

Note:

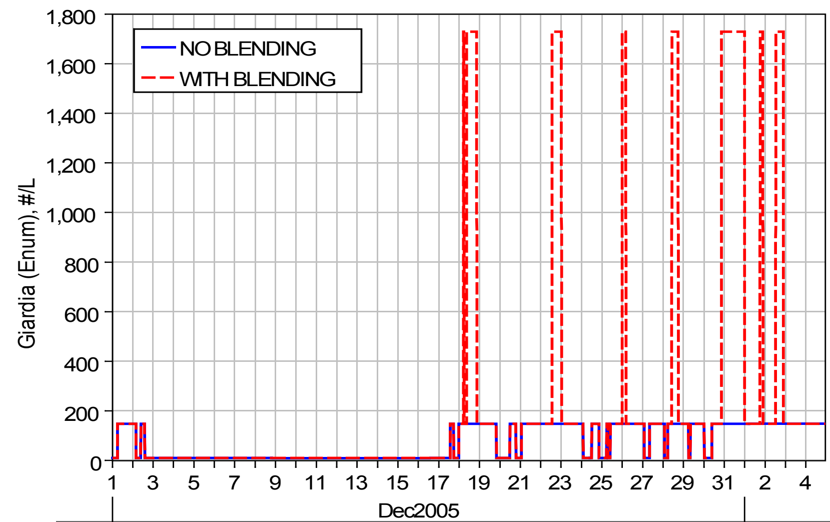
(1). Die-off rate was discussed with PSC in an initial conference call; a subsequent conference call with PSC members who expressed interest; and it was reviewed by Charles Gerba. $C_t = C_0 * e^{(-K\,t)}$

(2). The temperature range was based on USGS data for San Francisco Bay during wet season from December to April.

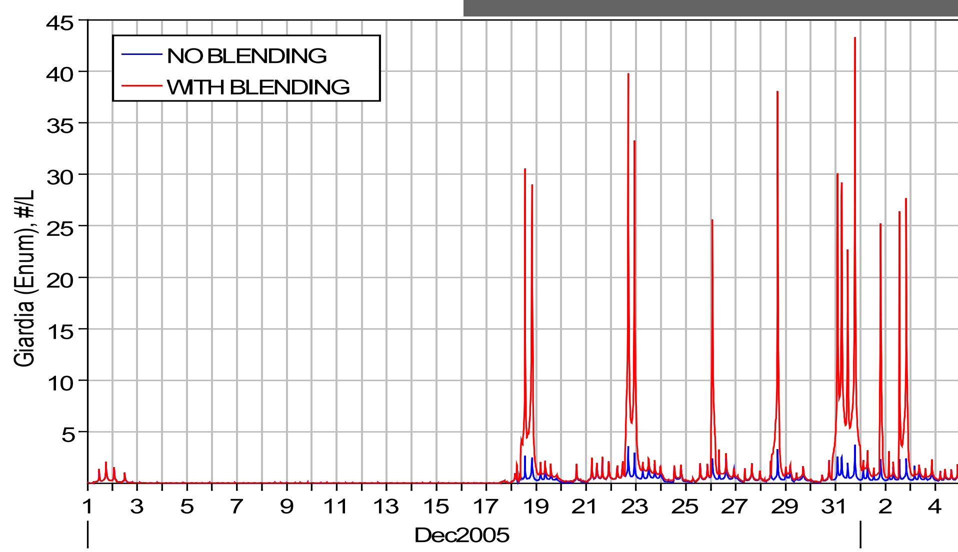
Example: SF Bay Modeling Input and Output (Giardia, worst case)



Plant Final Effluent Flow



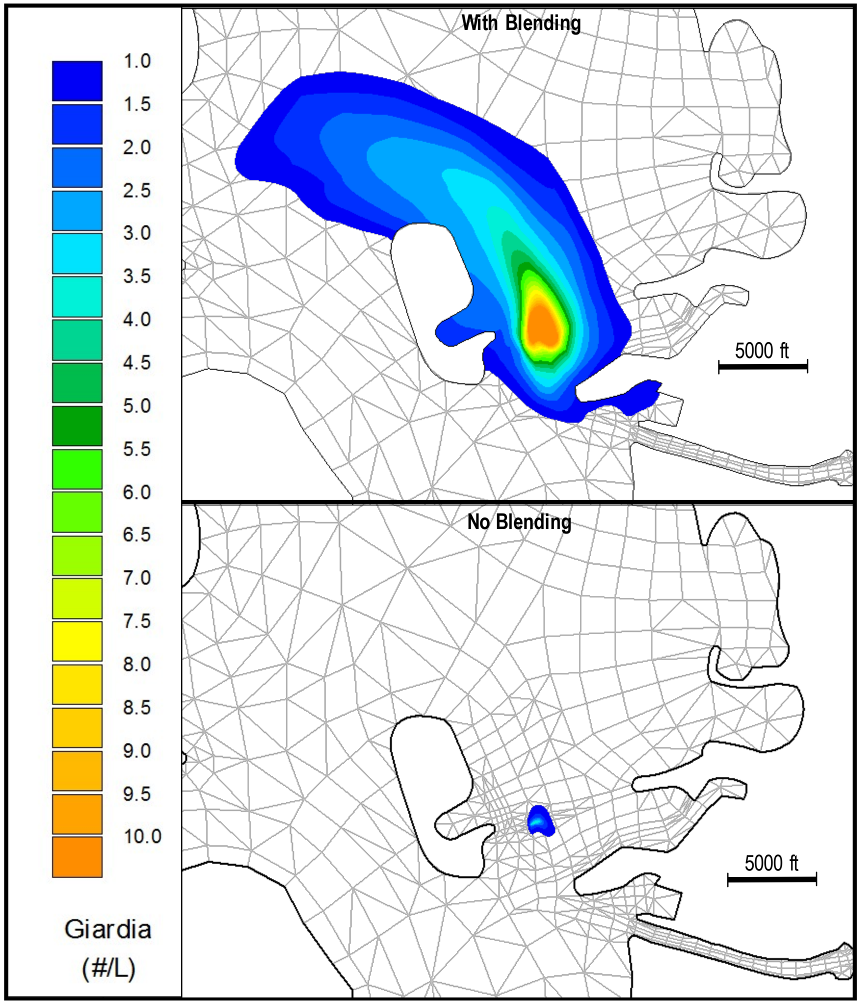
Giardia Concentration assumed for the Final Effluent Flow

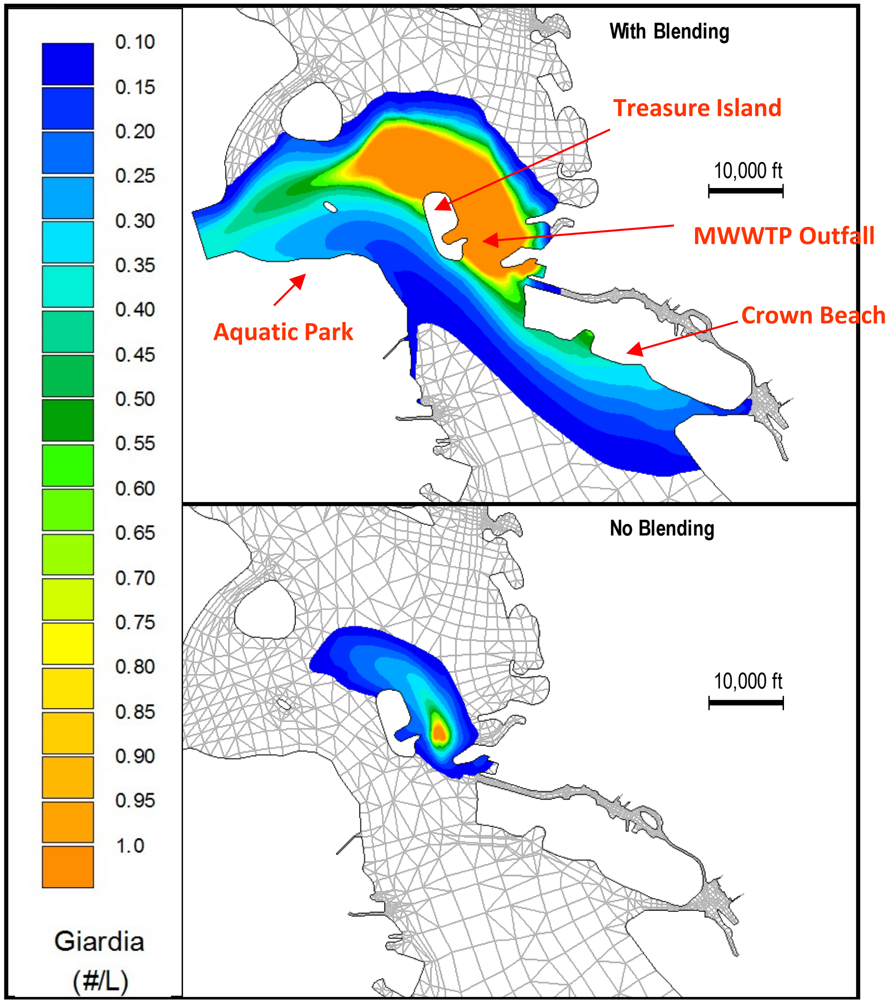


Simulated *Giardia* Concentration at EBMUD Outfall

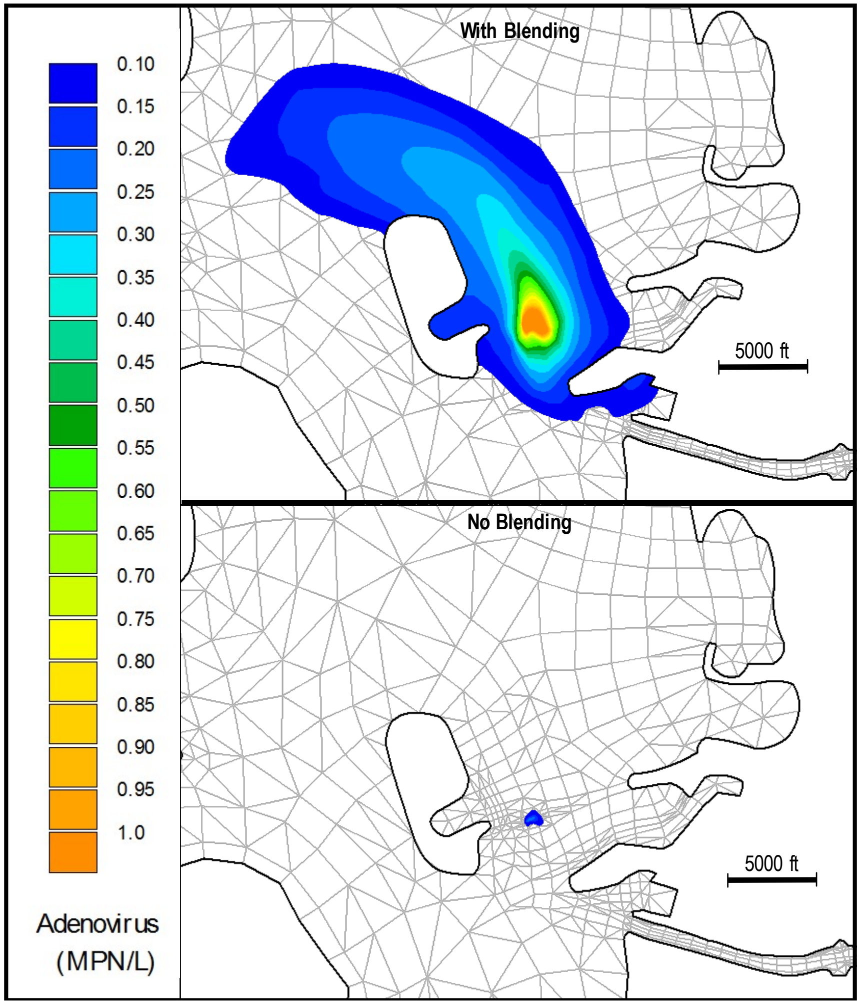
SF Bay Modeling Contour Results (worst case, *Giardia*, at time of peak concentration, Dec 31, 2005)

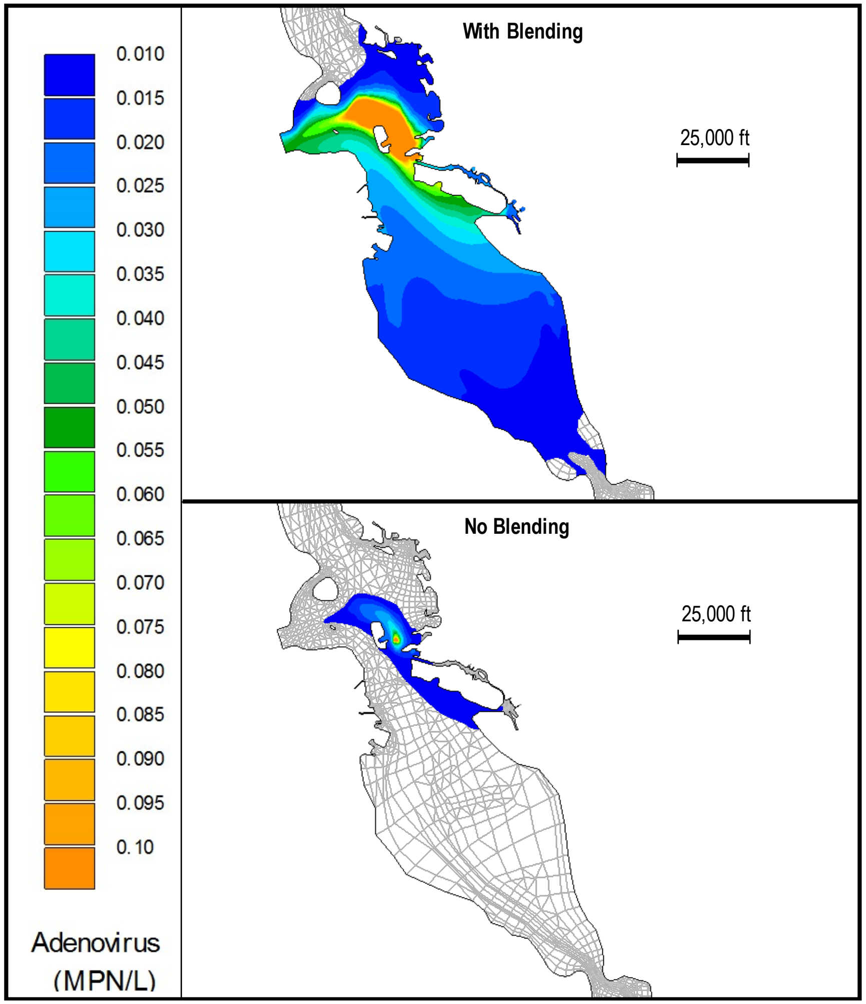
Note the different concentration scales



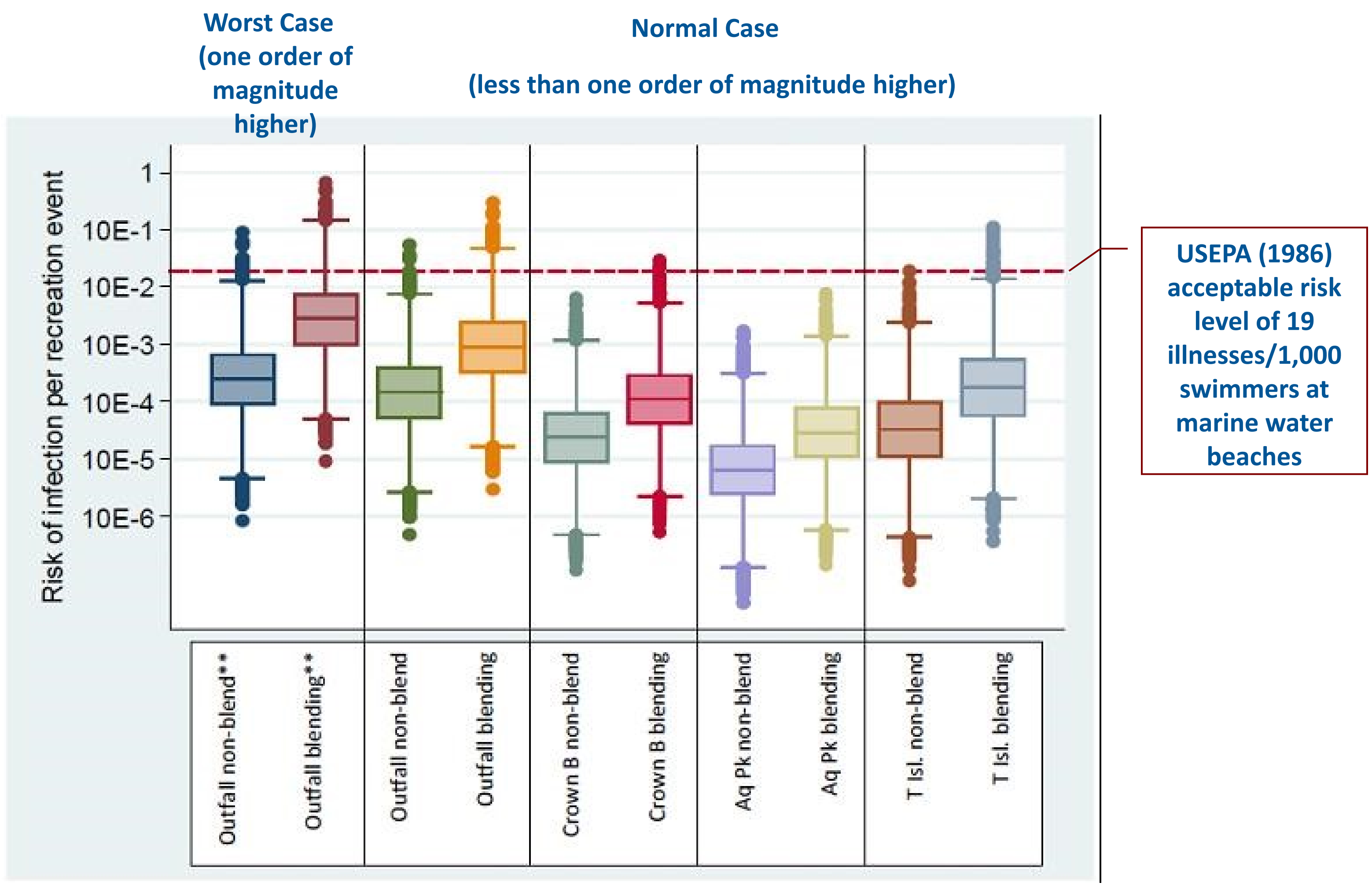


SF Bay Modeling Contour Results (worst case, adenovirus, at time of peak concentration, Dec 31, 2005)

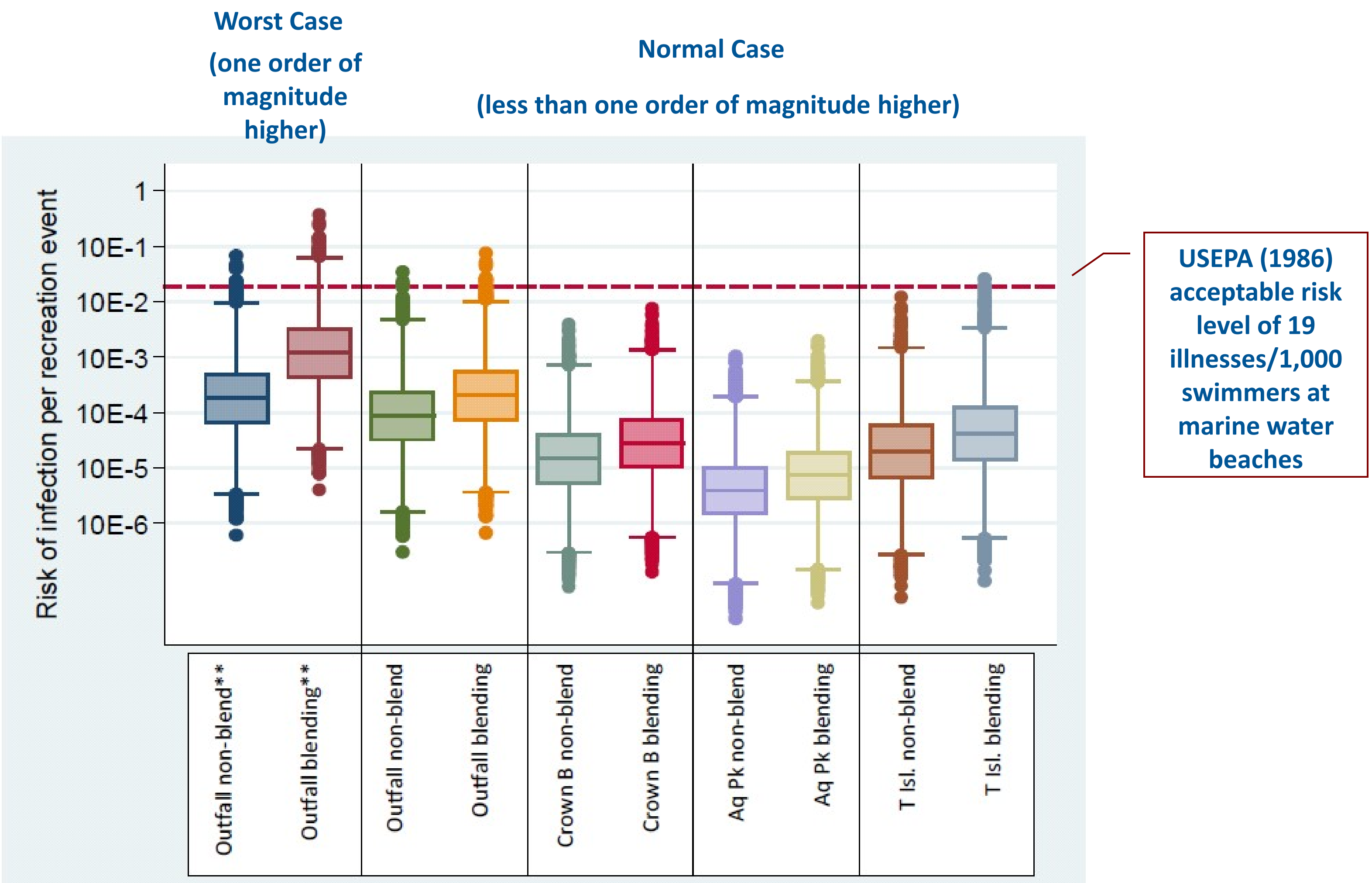




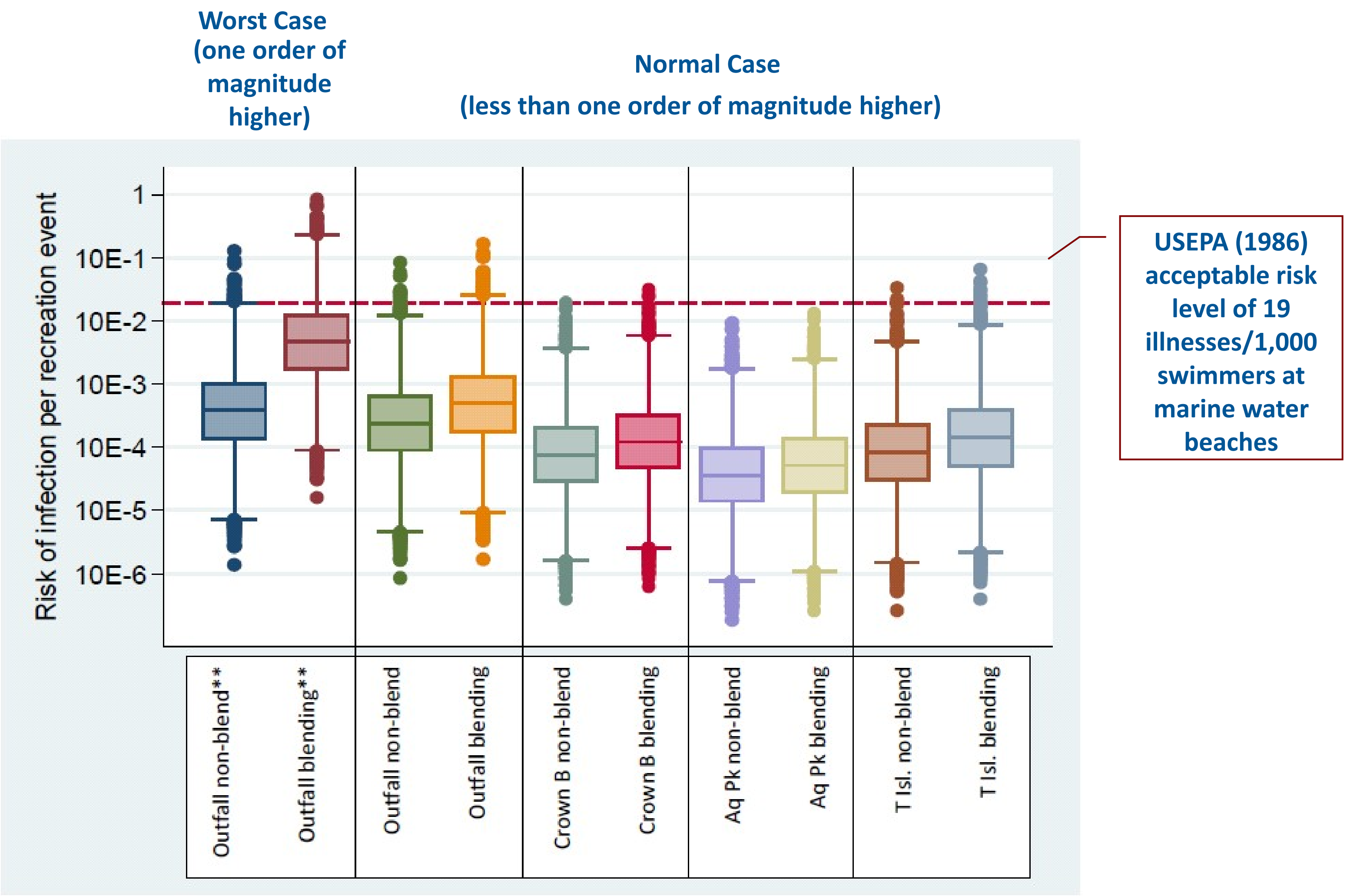
Results of Microbial Risk Assessment (*Giardia*, blending vs. non blending)



Results of Microbial Risk Assessment (*Giardia PI-negative*)



Results of Microbial Risk Assessment (adenovirus)

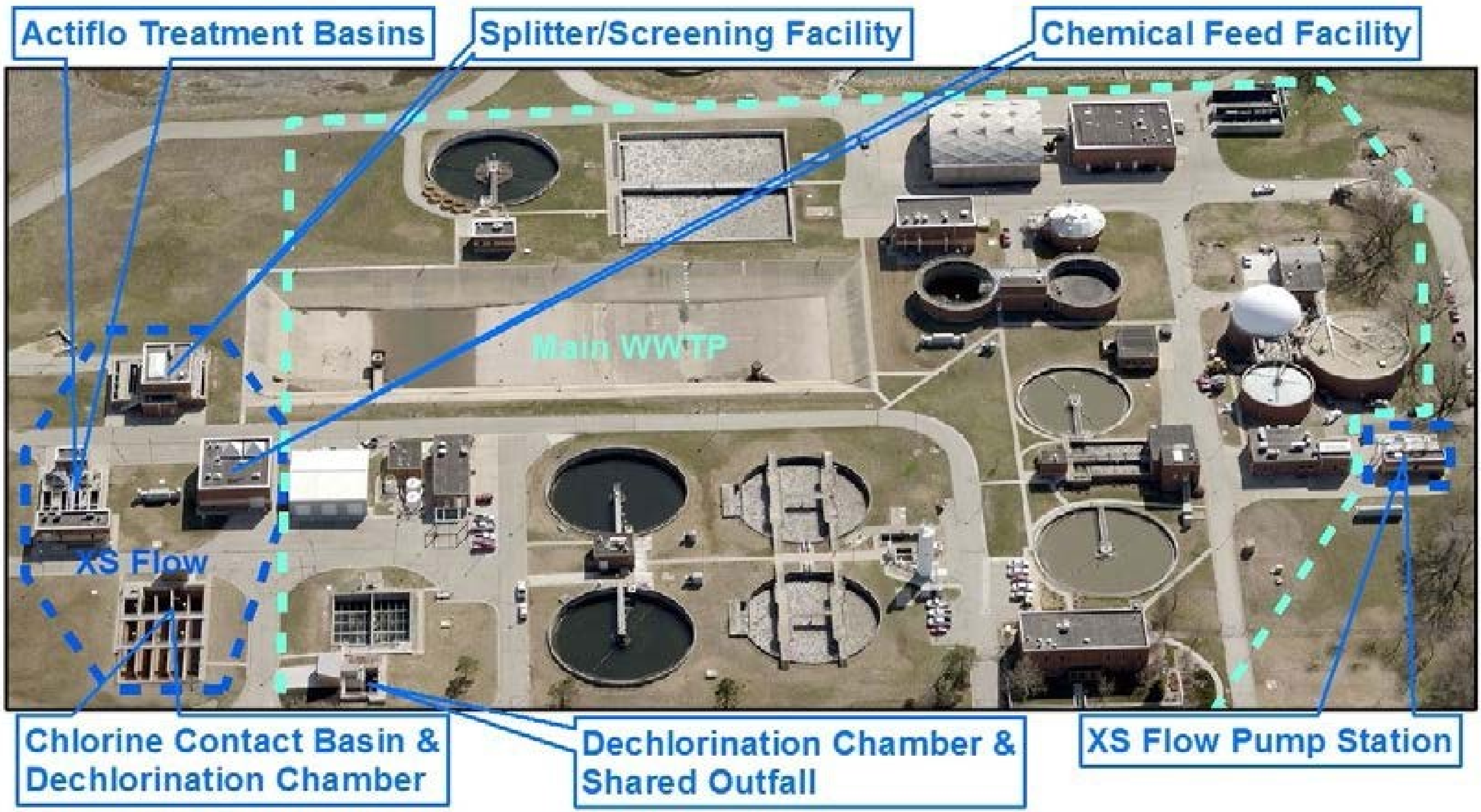


Lawrence, Kansas

Background and milestones

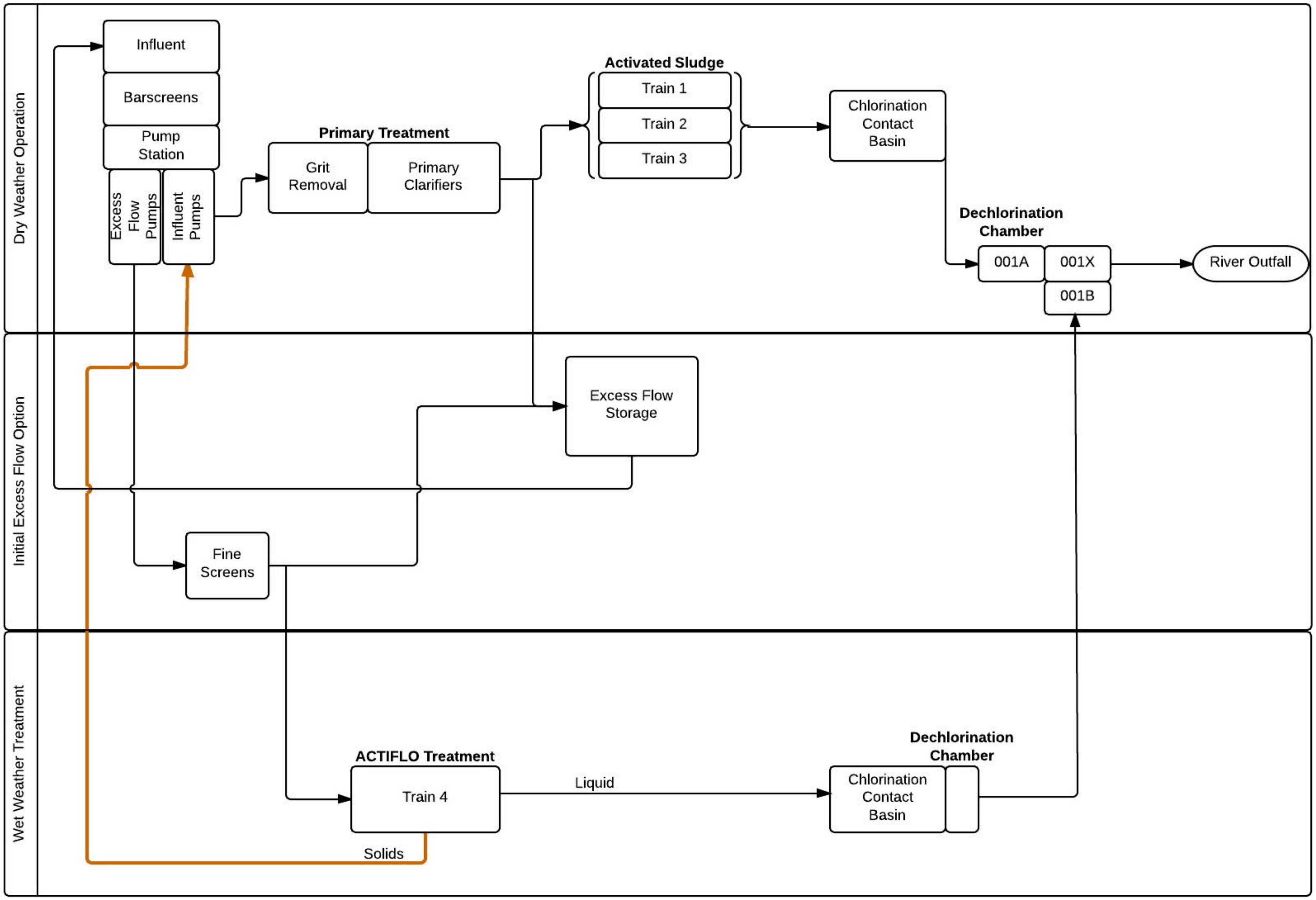
- **1974 – Wet-weather storage basin included with upgrades at WWTP.**
- **1998 – Proactive sewer maintenance program**
- **2003 – WWTP expansion and upgrade, including auxiliary wet-weather flow treatment facilities.**
- **Ongoing commitments and investments include:**
  - Design for new 2.5-mgd WWTP with BNR and additional 5-MG peak flow storage.
  - Additional I/I reduction initiatives
  - Adoption of Integrated Plan under MOU with KDHE

Kaw River WWTP



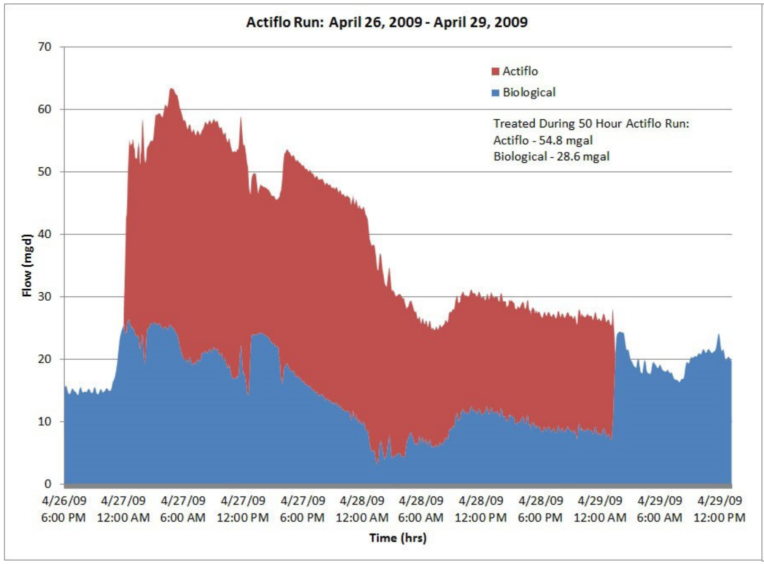
- 9-mgd dry weather
- 11-mgd annual average
- 16-mgd maximum monthly
- 65-mgd peak hourly

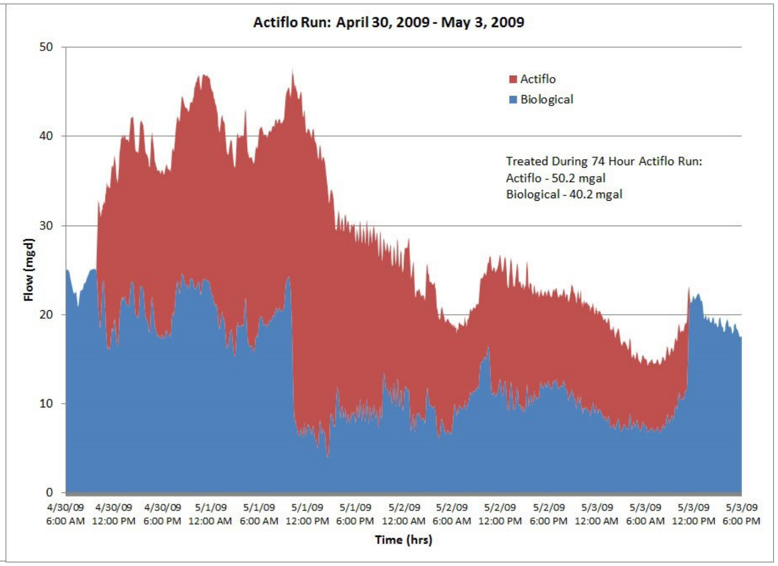
Kaw River WWTP Process Flow Diagram



Summary of treatment from 2004 to 2014

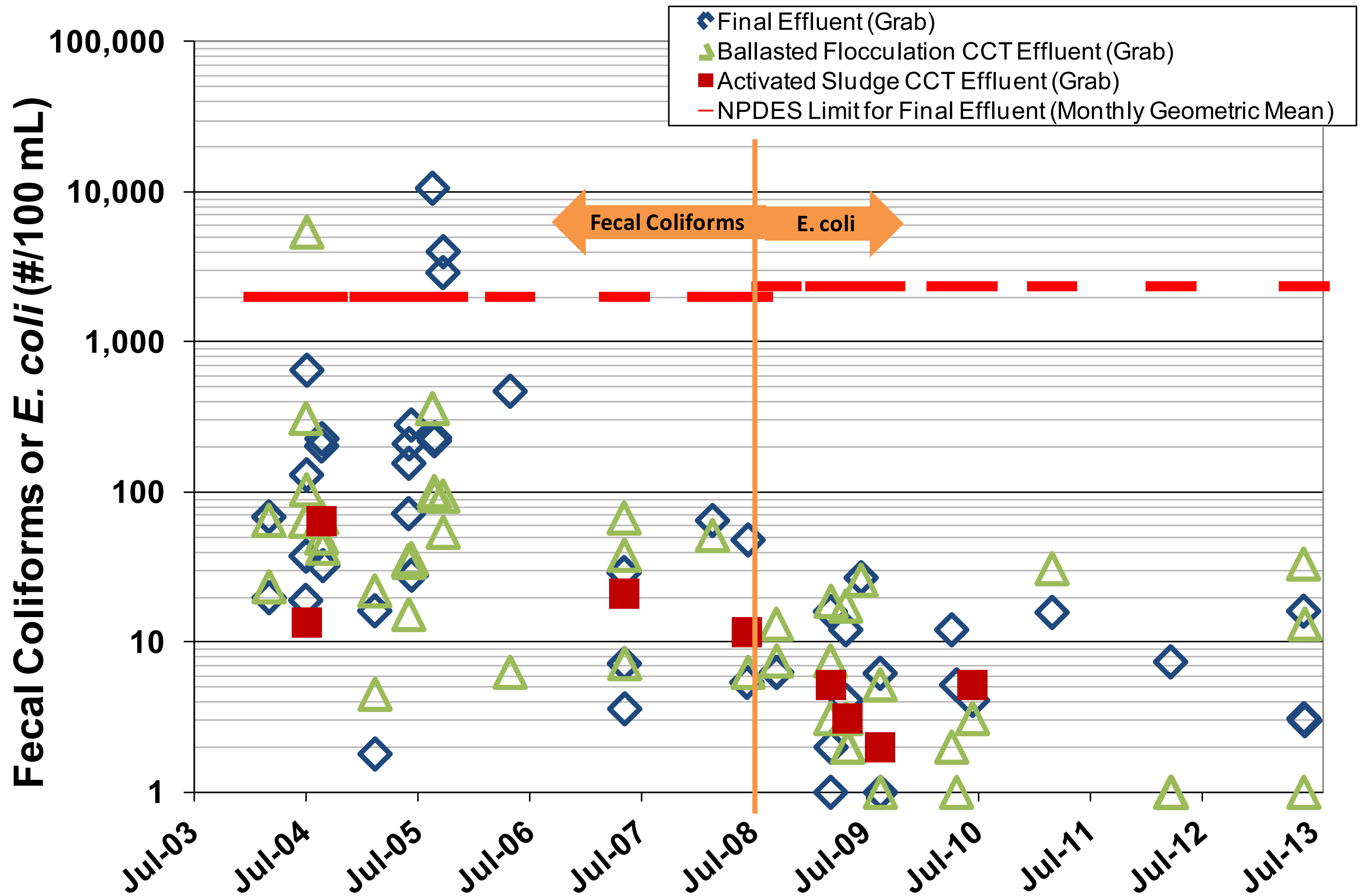
- 36,432 MG treated through biological trains (98.2% of total)
- 670 MG treated through HRC trains
- HRC discharged a total of 52 days in 10 years (1.4% of the time)





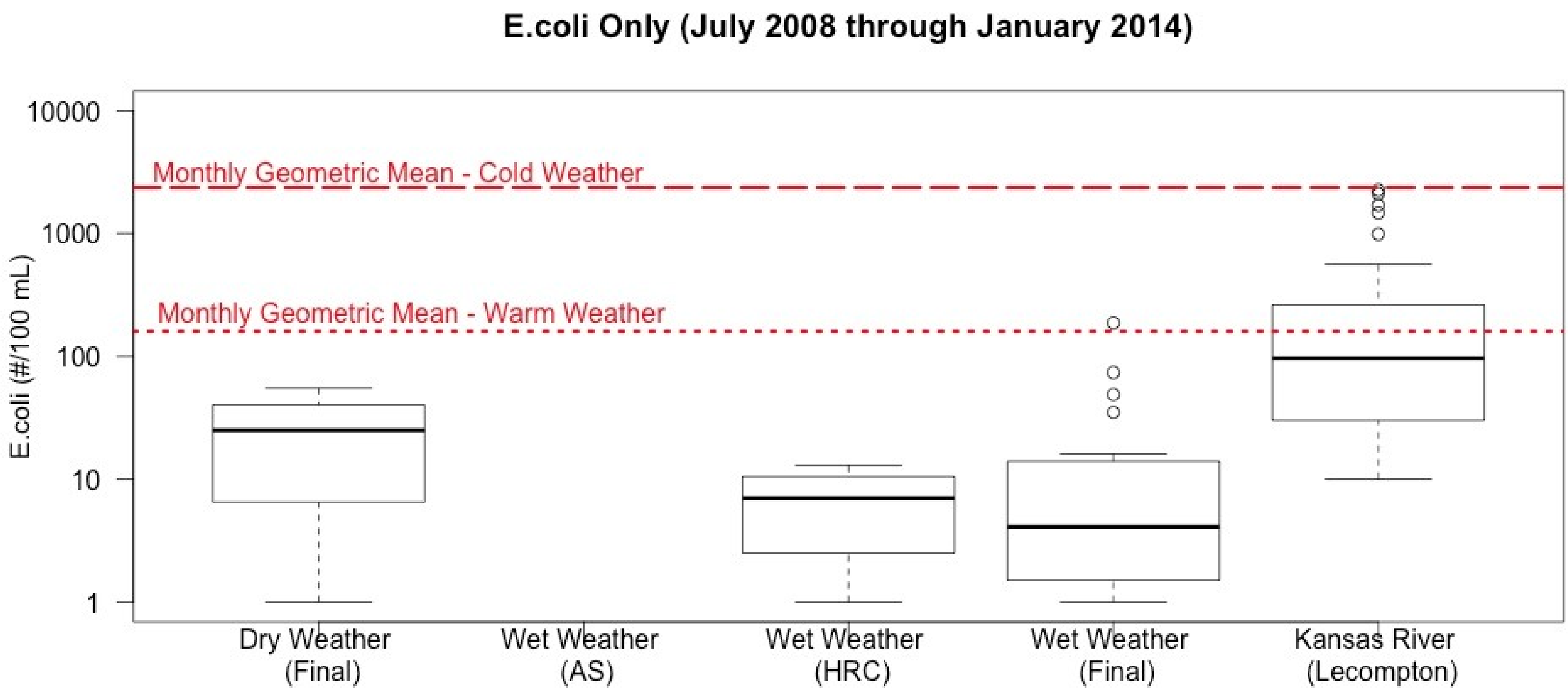
Hydrographs from back-to-back auxiliary HRC runs during 7-day period in April/May 2009

CONSISTENTLY COMPLIANT EFFLUENT DISINFECTION



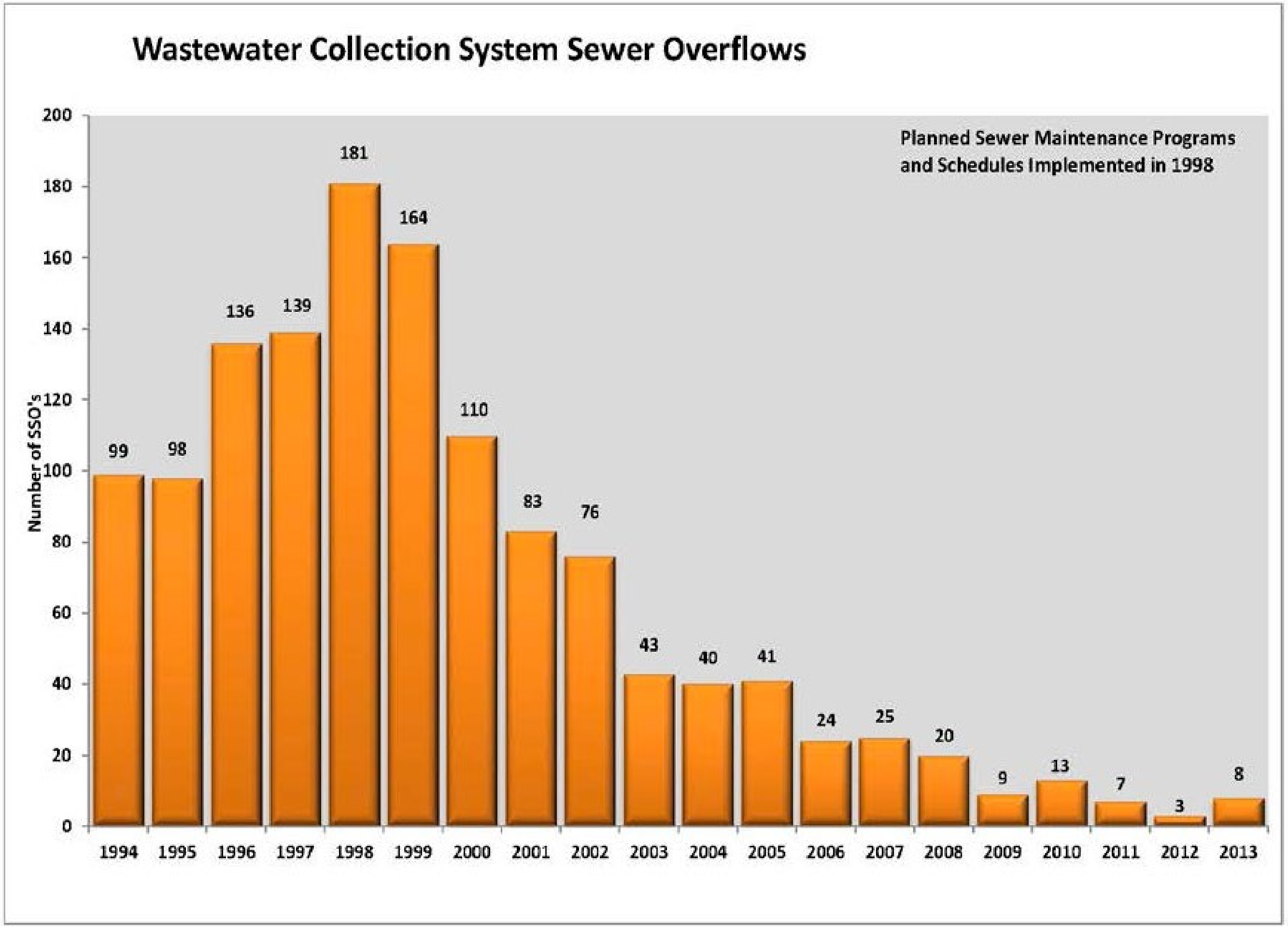
Fewer wet-weather excursions from HRC than from activated sludge train.

Effluent coliform concentrations during auxiliary treatment < normal dry weather < upstream background



Suggests that public health risks from wet weather discharges are even lower than during normal dry weather operations.

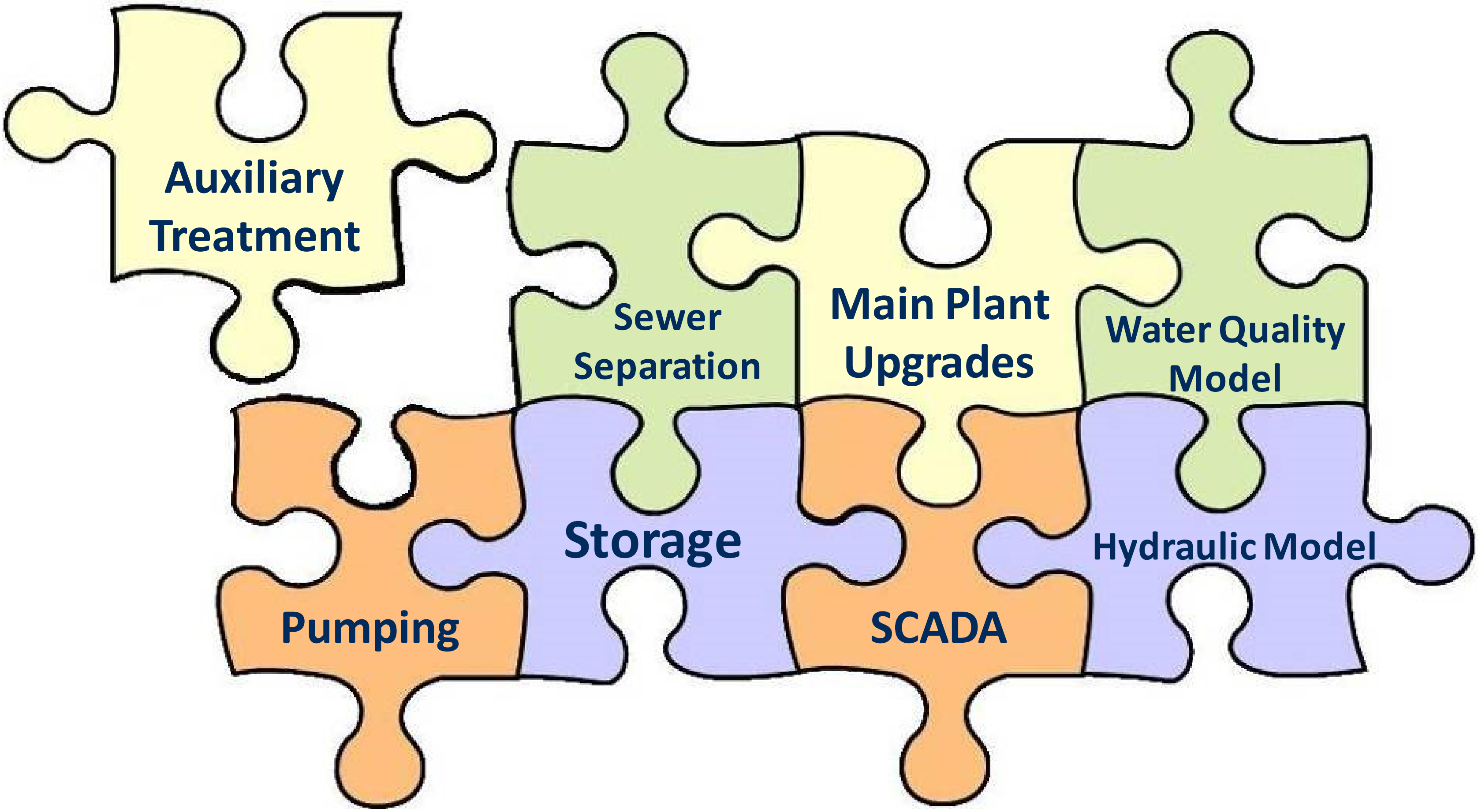
Collection system maintenance and WWTP capacity upgrades have resulted in elimination of vast majority of SSO



One measure of success

Toledo, Ohio

Auxiliary treatment is part of the solution



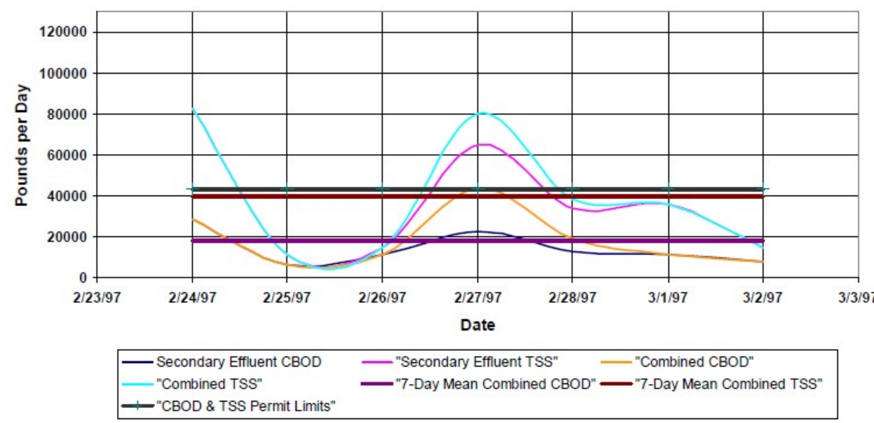
Background and milestones

- 1993 – Completed 20-MG in CSO storage tunnels
- 2002 – Start of Toledo Waterways Initiative. 18-yr wet weather program to invest $521 million on three major areas:
  1. Auxiliary wet weather storage and treatment to eliminate WWTP bypasses
     - 2007 – completed construction
     - 2009 – completed 2-yr performance study
     - 2011 – began pathogen study (ongoing)
  2. Relief sewers and storage to eliminate SSO
     - Completed in 2013
  3. Implement LTCP to reduce CSO
     - Complete by 2020

Plus ongoing operation and maintenance of existing infrastructure

Comprehensive evaluation with dynamic modeling helped optimize storage and auxiliary treatment sizing

- **Objectives**
  - Biological treatment of 99.5% of influent volume in typical year
  - Auxiliary HRC to increase treatment capacity to 400 mgd
  - Meet existing permit limits
- **Results**
  - Reduce WRF storage from 60 to 25 MG
    - First-flush capture
    - Lower duration of stress on activated sludge train
  - Defer secondary clarifier expansion



Dynamic modeling predicted compliance with all permit limits for 15 different maximum 7-day wet-weather scenarios. (Lyon, 2005)

Dynamic model demonstrated better and more reliable effluent quality with smaller storage basin

Wet weather storage and auxiliary treatment at Bay View WRF

Reaeration
Chlorination
Dechlorination

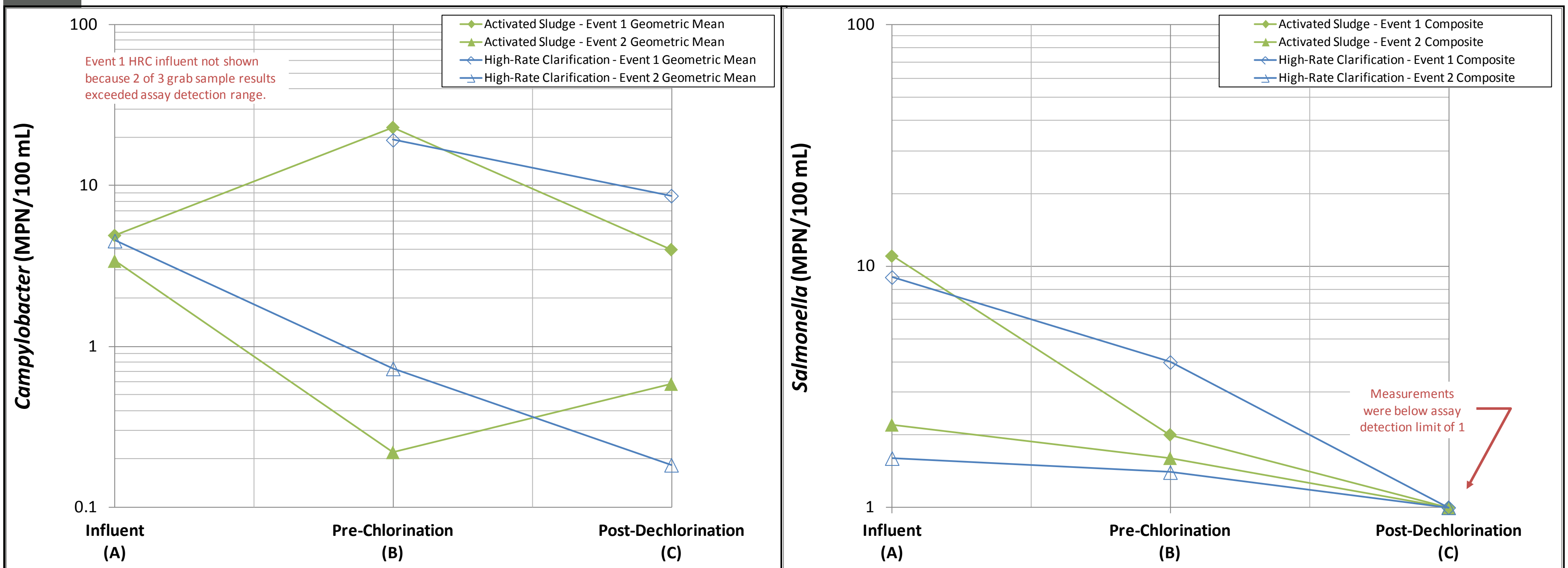
25-MG
Storage
Basin

232-mgd HRC

232-mgd Grit
Removal

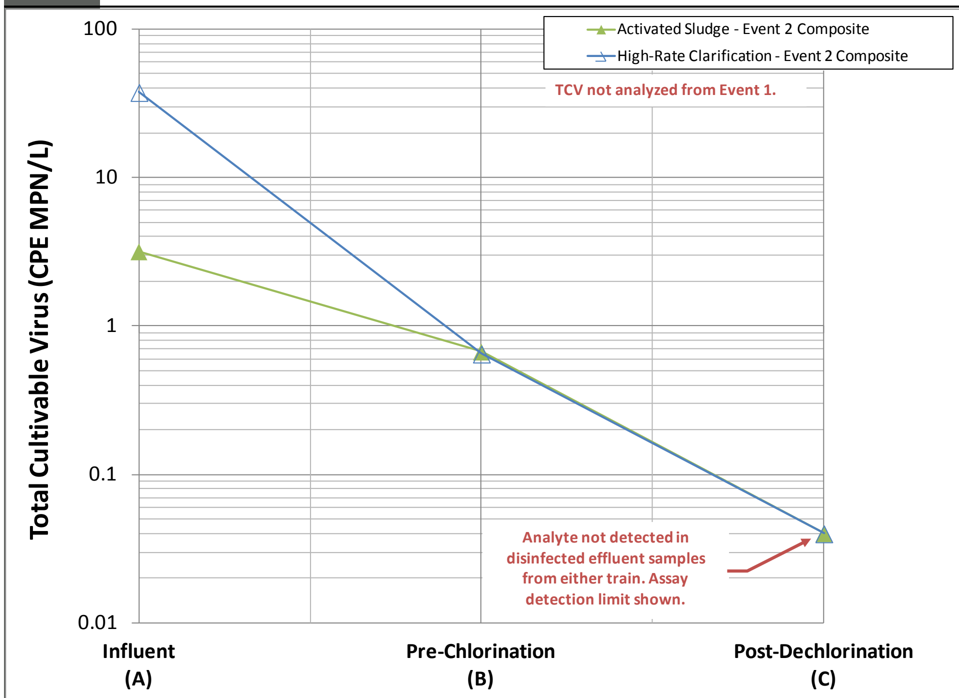
- 45 mgd dry weather
- 70 mgd annual average
- 130 mgd maximum monthly
- 400 mgd peak hourly

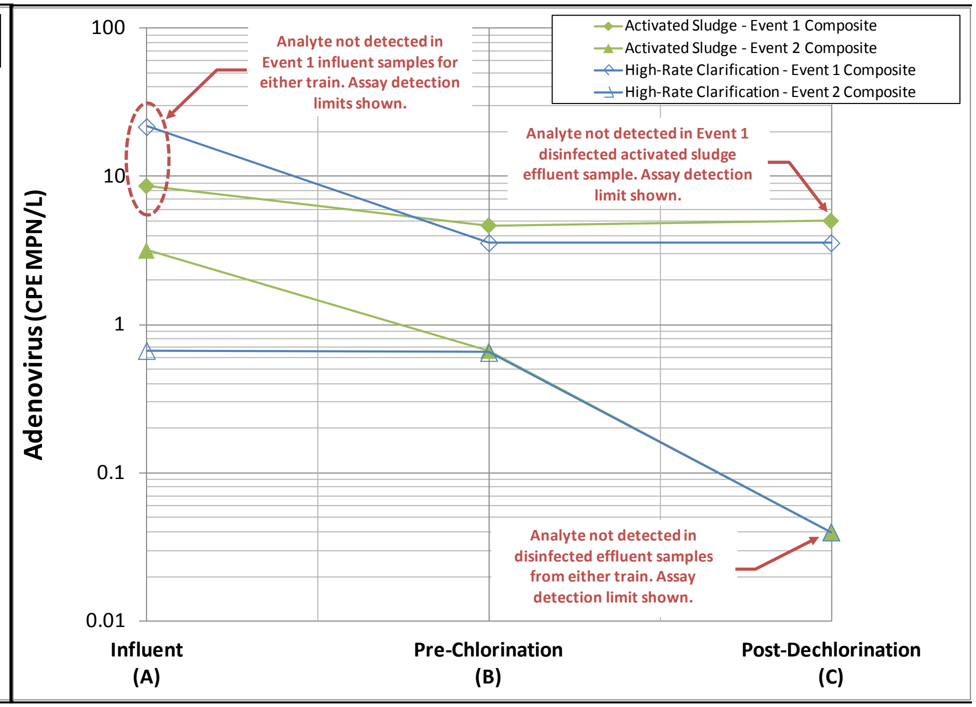
Preliminary results – pathogenic bacteria



Qualitatively similar reductions through activated sludge and HRC trains. Statistical analysis planned after 3rd event.

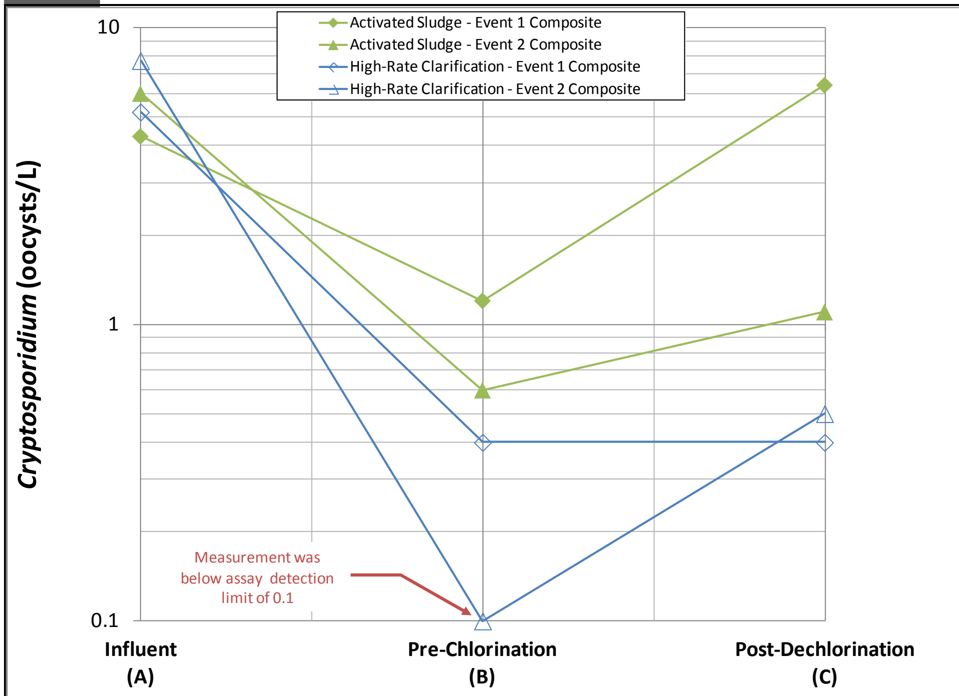
Preliminary results – pathogenic viruses

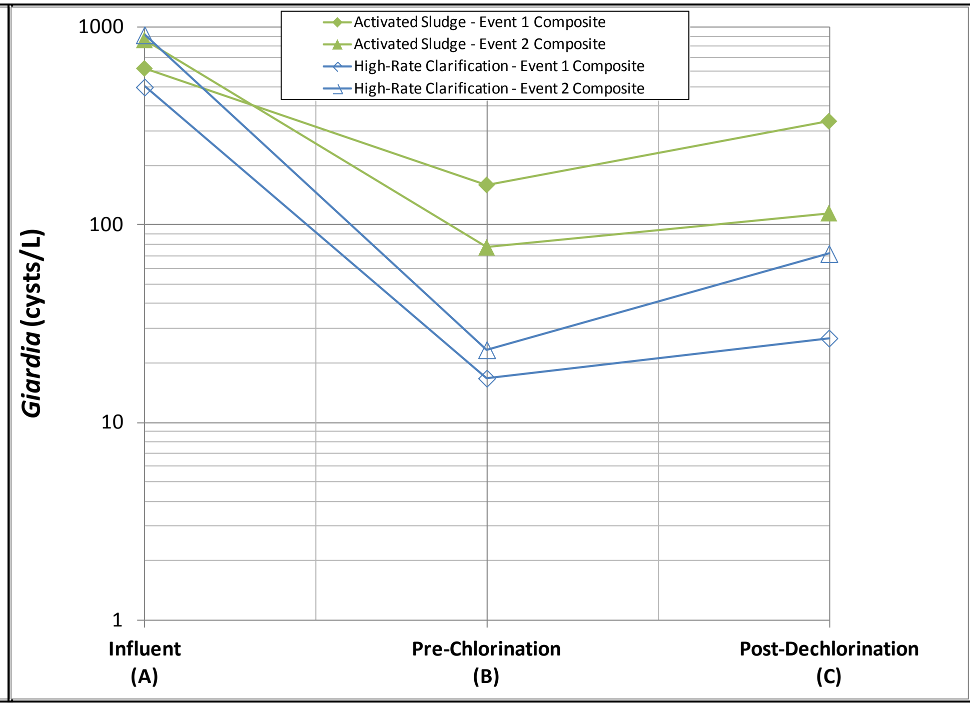




Similar reductions through activated sludge and HRC trains.

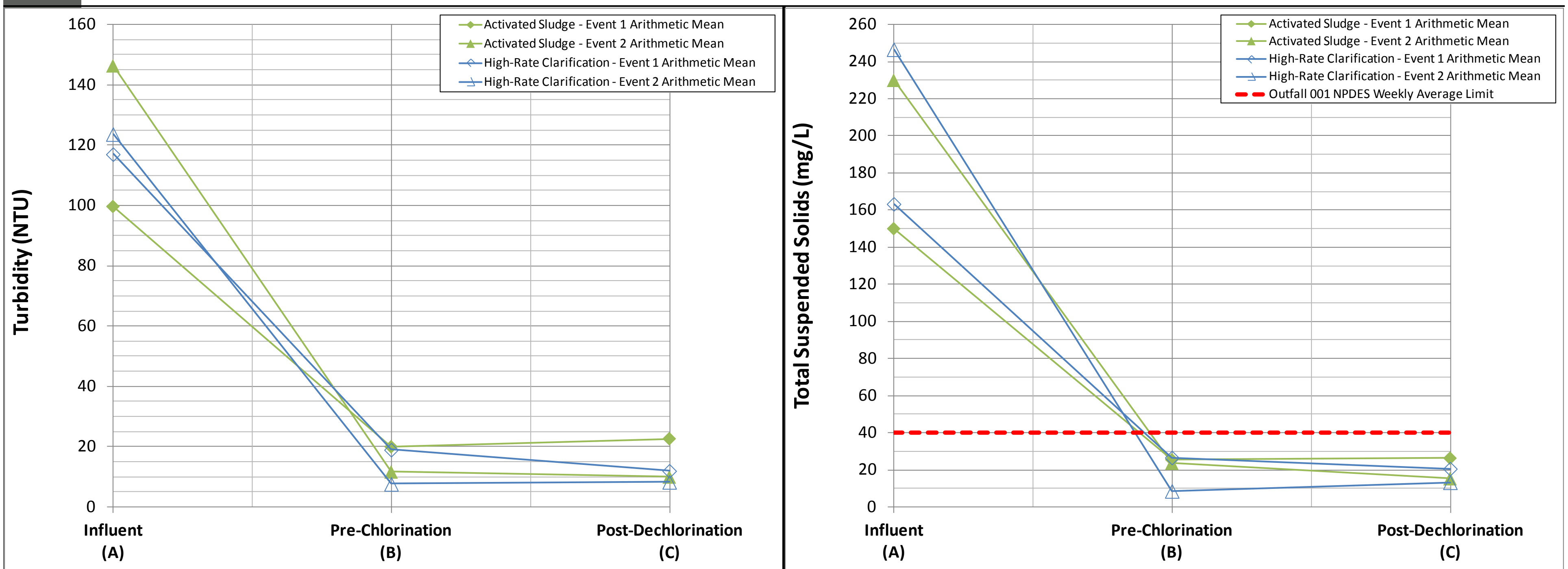
Preliminary results – pathogenic protozoa





Perhaps slightly greater reduction through HRC.

Preliminary results – turbidity & TSS



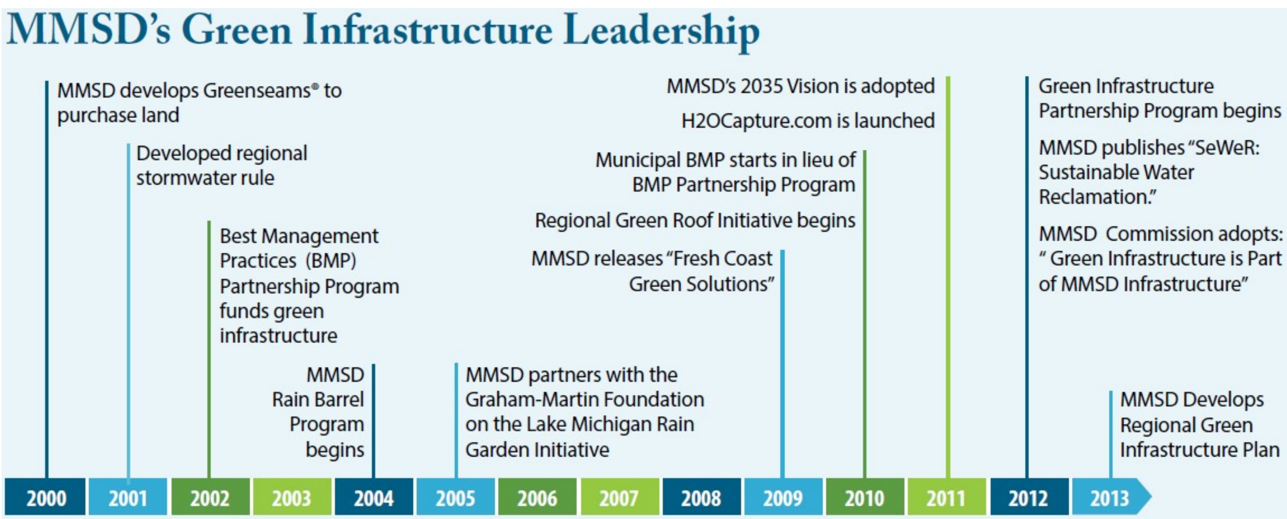
Slightly greater reduction through HRC.

Milwaukee MSD

USEPA Experts Forum on Public Health Impacts of Wet Weather Blending

Background and milestones

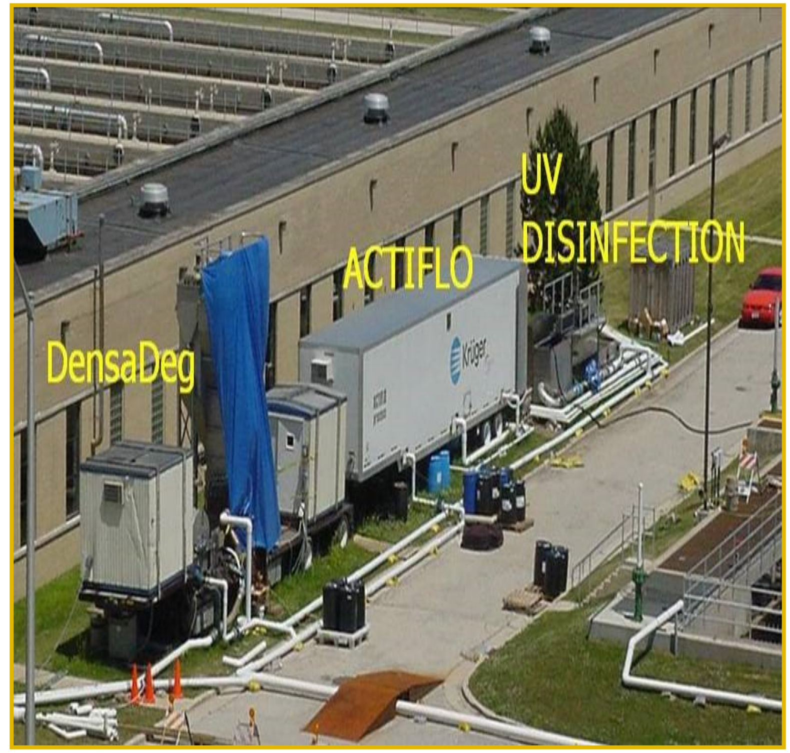
- 1990s – Added Inline Storage System (ISS). 19-mile network of deep tunnels and pump station.
- 1990s – Began implementing green infrastructure strategies.
- **2006 – EHRT piloting of CEC and UV disinfection technologies.**
- 2007 – Completed 2020 Facilities Plan
- 2011 to 2013 – EHRT piloting extended to CES, biocontact and CMF technologies.
- 2014 – Begin developing 2050 Facilities Plan



Source: MMSD *Regional Green Infrastructure Plan* (June 2013)

Milwaukee MSD - Chemically Enhanced Clarification Demonstration Testing

- Location: MMSD's South Shore WRF
- Piloted: ACTIFLO, DensaDeg, UV
- Treated primary influent
- 240–300 gpm/HRT unit
- 12 Weeks (April – June, 2005)
- Dry weather testing and wet weather testing (2 events)



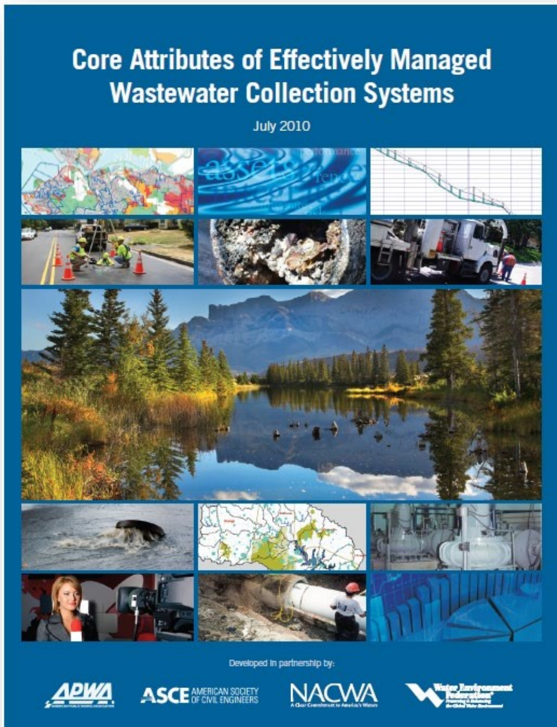
HRC + Disinfection Compared to Existing Activated Sludge + Disinfection

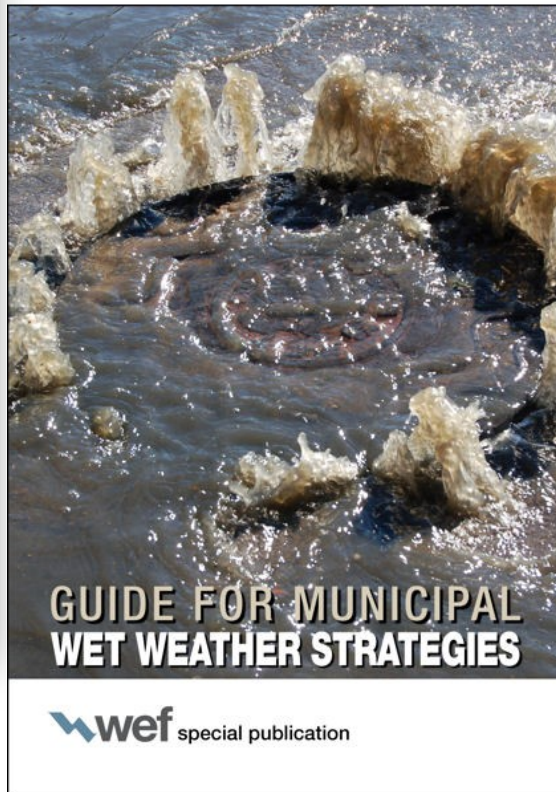
Treatment Processes	*E. coli* Reduction	Fecal Coliform Reduction	F+ Coliphage Reduction
CEC + UV Pilot Test	3 to 4 log	3 to 5 log	3.5 to 4 log
Activated Sludge + Chlorine Disinfection at South Shore WRF	3 to 4 log	3 to 5 log	3 to 3.5 log

- **CEC/UV reduction for *E. coli,* fecal coliform, and F^{+} coliphage similar to existing 1° & 2° treatment with chloramination**
- **Reduction of adenoviruses and enteroviruses by UV disinfection at 40 mJ/cm^2 similar to chloramination**

Recent guidance documents

Wet-weather challenges require site-specific plans, designs and management





To be published in October 2014:

Wet Weather Design and Operation in Water Resource Recovery Facilities

wef special publication

Recent POTW guidance for holistic and sustainable wet-weather solutions.

Summary points

- Wet weather events have a short duration and are infrequent. Risks tend to be acute, not chronic.
- Reducing peak flows to POTWs to a level that allows for effective treatment by traditional biological processes alone may not always be practical.
- If needed, wet weather flows could be treated effectively by physical and/or chemical methods to address acute water quality concerns.
- POTWs blended discharges may have a lesser impact than non-point source contributions.
- Site specific variables result in site specific impacts and thus require site specific solutions.
- POTW planning, design and operations guidance have been updated to develop and select optimum site-specific alternatives for wet-weather management.
- The known risks to public health from well-designed and operated blending facilities appears to be relatively low. Many of the recent regulatory drivers and concerns from the public appear to be caused by misinterpretations or misunderstandings about the practice and treatment processes. We hope our discussions today and tomorrow help shed much needed light on this topic.